PUBLIC DOCUMENT . . . . No. 33.

ELEVENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1899.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are : —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B.Sc.,	*Assistant Entomologist.*
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 37. Report on fruits, insecticides and fungicides.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
No. 50. The feeding value of salt-marsh hay.
No. 51. Fertilizer analyses.
No. 52. Variety tests of fruits; spraying calendar.
No. 53. Concentrated feed stuffs.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 56. Concentrated feed stuffs.
No. 57. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can only be supplied to complete sets for libraries.

New methods and new appliances in the feeding and care of animals and plants have opened up new problems, and the demands made upon the station have taxed it to its uttermost. Briefly summarizing the work of the year, we find it distributed as follows: in the division of foods and feeding a new feature has been added, viz., regulating the sale of concentrated feed stuffs. There have been 663 analyses of these materials made, 292 of fodder and 420 of dairy products. In an investigation of Cleveland flax meal *v.* old-process linseed meal for feeding early lambs, it was found that no injurious results followed from the use of flax meal, and that there was the same average daily growth of the lambs on either ration; in an experiment of corn meal *v.* hominy meal and corn meal *v.* cerealine feed for growing pigs, it was found that the corn meal was five to ten per cent. more valuable than cerealine feed used in connection with skim-milk, while hominy meal was quite as valuable as corn meal in connection with skim-milk.

In the entomological division, besides the special work in connection with the gypsy moth, attention has been paid to combining the arsenate of lead and the Bordeaux mixture, with favorable results. The life histories and habits of two pernicious insects have been worked out, — the grass thrips, particularly destructive in this State, and the small clover-leaf beetle (*Phytonomus nigrirostris*). The pernicious scale insects (*Chionaspis*) have also been carefully studied, and the results will soon be published.

The horticultural division has continued its work of testing varieties of fruits, domestic and foreign, suitable for this State, and its investigation of hydrocyanic acid as an insecticide.

The division of fertilizers has made five hundred and fifty-two analyses; has conducted experiments on the use of concentrated chemical manures to supply plant food in greenhouses, combinations of high-grade fertilizers for garden, greenhouse and pot cultivation; and has made observations with dried blood and two kinds of leather refuse as a source of nitrogen for growing rye in presence of acid and alkaline phosphates.

The agricultural division, in addition to its soil tests with corn, onions, oats, etc., has undertaken the testing of seeds of the same variety of potatoes raised in different localities, finding a variation of fifty per cent. in Early Rose and Beauty of Hebron. In experiments with poultry the following results were obtained with reference to egg production: (*a*) that condition powders had no effect; (*b*) that animal meal was of more value than cut bone; (*c*) that the influence of the cock was *nil;* (*d*) that a wide ration was preferable to a narrow ration.

The botanical division has issued an illustrated bulletin (No. 55) on the nematode worm, in which its life history is traced, and a simple remedy, steaming the soil, given for its repression. Work has been done in the drop and top burn of lettuce, asparagus and chrysanthemum rust, and in sub-irrigation and the mechanical condition of soil as affecting the growth of lettuce.

Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1898.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,443 00	
for labor,	3,605 36	
for publications,	2,885 54	
for postage and stationery,	235 56	
for freight and express,	355 49	
for heat, light and water,	130 17	
for seeds, plants and sundry supplies,	448 72	
for fertilizers,	285 86	
for feeding stuffs,	141 17	
for library,	244 78	
for tools, implements and machinery,	250 00	
for furniture and fixtures,	105 19	
for scientific apparatus,	228 36	
for live stock,	901 00	
for traveling expenses,	220 00	
for contingent expenses,	80 65	
for building and repairs,	439 15	
		$15,000 00

Cash on hand July 1, 1897,	$19 73	
Received from State treasurer,	11,200 00	
from fertilizer fees,	3,278 75	
from farm products,	1,763 86	
from miscellaneous sources,	1,663 45	
		$17,925 79
Cash paid for salaries,	$8,901 77	
for labor,	3,167 18	
for publications,	708 27	
for postage and stationery,	236 16	
for freight and express,	154 97	
Amount carried forward,	$13,168 35	

Amount brought forward,	$13,168 35	
Cash paid for heat, light and water,	549 44	
for chemical supplies,	958 54	
for seeds, plants and sundry supplies,	368 02	
for feeding stuffs,	592 46	
for library,	191 10	
for tools, implements and machinery,	34 49	
for furniture and fixtures,	40 23	
for scientific apparatus,	187 11	
for live stock,	313 50	
for traveling expenses,	356 73	
for contingent expenses,	163 96	
for building and repairs,	1,001 86	
		$17,925 79

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1898; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $32,925.79, and the corresponding disbursements $32,925.79. All the proper vouchers are on file, and have been by me examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1898.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 31, 1898.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

During the year, as in previous years, the meteorological division has been principally engaged in the observations of the various weather elements and phenomena, and the compilation of the records in permanent form. The more important results, together with summaries of most of the others, have been published, as heretofore, in bulletin form each month. The usual summary of the weather for the year will be issued when the records are completed.

The records of the division were begun with the year 1889; accordingly, this year completes the first decennial period. A tabulation of the results for the whole period is under way, for use in determining the means of the several weather elements at this station. These results should give normal conditions differing but little from those that may afterward be deduced from observations covering a much longer time, and will be found valuable for the purpose of determining departures from mean conditions in the future. The tables are being arranged in a suitable form for publication, so that they may be issued in bulletin form, if it is thought desirable.

While the self-recording instruments in the tower give generally good results, the records of the sun thermometer are lacking in precision. Cold-air currents and variable wind velocities give at times records which cannot be distinguished from those due to cloudiness. The desirability of having a photographic or an electrical sunshine recorder, for use in conjunction with the Draper instrument, is suggested.

The local forecasts of the weather have been received daily, except Sunday, from the Boston office of the United

States Weather Bureau, and the signals displayed on the top of the tower. At the request of Mr. J. W. Smith, director of the New England section of the United States Weather Bureau, this division has arranged to furnish his office the weekly snow reports, as has been done the past few years. The record of the number of days of sleighing, begun by Professor Metcalf, is being continued.

During the year attempts were made to secure some records of atmospheric electricity by using the quadrant electrometer in the tower, but without success. The extreme sensitiveness of the instrument seems to preclude its working at any such height from the ground, where it is necessarily subjected to the vibrations of the building. Unless a suitable location and mounting can be provided elsewhere, the records it was intended to secure cannot be obtained with any degree of success.

During the year the division purchased one of the resistance boxes made after the design of Prof. Milton Whitney, of the Division of Soils, United States Department of Agriculture, for the purpose of continuing the examination of soil moisture by the electrical method. The electrodes could not be obtained from the manufacturer until early in June, and then a number proved defective. Others were loaned us later by the Department at Washington for continuing the work. The results obtained have been even less satisfactory than those of last year. An examination of the electrodes in the soil showed in some cases short circuits to have been produced by the growth of roots across the face; in other cases no cause could be found for unusual changes in the resistance. A continuation of the experiment another year may perhaps furnish more satisfactory results, or reveal the causes of some abnormal fluctuations.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The work of this division during the past year has been carried on in about the same lines as for the year of 1897.

Of the experiments conducted, variety testing of fruits, vegetables, flowers, etc., has occupied considerable attention. This work has been undertaken largely in response to the constant calls from the people to know the value of widely advertised new varieties put upon the market with extravagant claims of merit and at exorbitant prices, nine-tenths or perhaps ninety-nine-hundredths of which prove of less value than the old established sorts.

Fruit Investigations.

The Apple.

With each succeeding year the fact is more and more clear that old varieties, from the many conditions of cultivation, from increased injury by insects and fungous pests, grow more feeble and are more and more subject to the continued action of the above agencies; and that new varieties must be found, that can be more easily and cheaply grown, or that will meet the demand for fruit of better quality. The Baldwin apple, for so long a time the most profitable and satisfactory variety for market, has in many places in the last two or three years shown so great a tendency to the dry-rot spots under the skin, long before its normal time for the breaking down of its tissues in the process of ripening, that much of its fruit put on the market has had the effect of decreasing the demand and lowering the price; while the Ben Davis, not nearly as good in quality, but firm, fresh and solid from skin to core, has been sold in our local markets to the exclusion of the home product.

The varieties of apples tested here and in many other sections, that stand out prominently as possessing those qualities that will enable them to successfully compete with the winter varieties shipped to our markets from other States, are the Sutton Beauty, Palmer, MacIntosh Red, Wealthy and Gano.

Sutton Beauty. — Much superior in quality to the Baldwin; is of similar color, perhaps not quite as large unless thinned, and has not shown the dry-rot spots so common in the latter variety. The tree is vigorous and compact in growth, generally with strong, healthy foliage, and so prolific as to require thinning. For local trade it is one of the best.

Palmer. — An apple of medium to large size, of a golden-yellow color when grown on trees in the full exposure of sunlight, but of a green color if grown on closely planted trees. It is of the best quality, tender, crisp and rich. Being an apple of light color and tender flesh, it should be handled very carefully when gathered, and sold in bushel boxes, in which it will not be subjected to much pressure or jolting.

MacIntosh Red. — This is one of the most beautiful of late fall and early winter apples, and, as far as it has been tested in Massachusetts, has done well, and promises to secure much of the trade for fancy apples that demands such varieties as the Fameuse, or Snow apple, which is not successfully grown in this State.

Wealthy. — Generally this variety has proved very satisfactory, but has only been grown on young trees. Its season of ripening is when there is an abundance of fall apples, but it often keeps into early winter. It colors up early, and its beauty, together with its fine quality and somewhat elastic texture, not easily bruised, makes it a good market variety, and should make it valuable as an early shipping apple with which to open the fall trade in European markets, which in the past has been greatly injured by shipping half-ripe and poorly colored Baldwins, and other varieties not as well colored or matured as the latter variety. It has thus far proved prolific, an early bearer and free from disease, but will be greatly improved by thinning.

Ben Davis. — It has been stated on good authority that more of this variety were sold in the Boston markets and on fruit stands during the winter of 1897 than of any other kind, almost the entire amount of which were imported from the western States. In quality and beauty this apple is far below any of the varieties above mentioned; yet its perfect form, uniform size, good keeping qualities, and its very firm, but somewhat elastic flesh, render it less affected by handling and shipping than almost any variety in cultivation. It is very productive, but, as grown in New England, unless thinned, will be of medium or small size. From its behavior thus far it would seem that, if a variety of so poor quality is to be demanded by our markets, it may be grown quite as successfully in many sections of the State as in any other section of the country. This, however, is not necessary; for, if the previously named varieties are well grown, there will be no difficulty in securing the local markets for them, if they are properly sorted and delivered.

Gano. — This variety was introduced as an improved Ben Davis, and, as far as tested, has proved superior to that variety in color, and perhaps to a very slight degree in quality. As yet it has only been produced on young trees, so that its real value cannot be determined without many years' further trial.

Pears.

With the large number of kinds of choice fruit that is now competing with the fruit grown in New England, the pear seems to be less in demand than formerly. Fewer varieties also are found profitable than a few years ago. Of those that stand at the head of the list, the Bartlett, Bosc, Sheldon, Seckle and Hovey are the most generally grown and bring the highest prices.

Peaches.

The interest in peach growing in this State seems on the increase, and the growers are coming to see that it is useless to plant the peach for profit except on high land, where a moderately vigorous growth can be maintained, and where the temperature is such that the fruit buds mature more fully and are not so liable to be destroyed by extreme cold. The varieties that are popular in the market and that are most profitably and successfully grown are Crawford's Early, Crawford's Late, Old Mixon, Elberta and Crosby. All of these varieties except the Elberta have long been grown in Massachusetts. The latter is an oval peach of large size and of a light-yellow color, with more or less color on the exposed side. It is generally hardy and productive, but the past season, in a great many sections of this and other States, was so seriously injured by the "leaf curl" as to endanger its vitality. Should it continue to be attacked by this disease, it will not long remain a profitable variety.

Plums.

Many growers of this fruit in the State have become discouraged from the lack of profit in the domestic plum, on account of the black knot, plum curculio, leaf blight and brown rot. The results obtained in the station orchards give no reason for such discouragement. Trees of all ages, from thirty years old to those of one or two years' growth, may be found, and almost every variety of any value is represented. Upon these trees will be found hardly a knot to the tree. No leaf blight appeared on the majority of the trees, and many varieties matured their fruit with little or no injury from the brown rot, while a few others were seriously injured. In the average season the use of the Bordeaux mixture, as recommended in the spraying calendar in Bulletin 52, has been found to prevent even the serious injury of the fruit by the brown rot; and the past season, had one or two applications of the copper sulphate solution (one-fourth pound to fifty gallons of water) been made the last of July or in early August, this loss might have been greatly reduced. The black knot has almost wholly succumbed to the treatment outlined in the bulletin mentioned, and the most healthy and vigorous foliage is to be found upon all the trees. The varieties that show the greatest tendency to rot are Lombard, Washington, Gueii, Smith's Orleans and Victoria. Those that show the least are Bradshaw, Prince Englebert, Kingston, Grand Duke, Reine Claude and Fellemberg. The amount of rotting of many varieties, however, is largely dependent upon the weather at the time of their approaching maturity, and only prompt and frequent spraying at this time will save the crop.

Of the newer varieties, those that show the most promise are the Kingston, Lincoln and Fellemberg.

Kingston. — Fruit very large, oval in form, slightly pointed at both ends, of the brightest blue color, firm in texture and very acid in quality; ripens late in the season and hangs a considerable time on the tree; very productive and valuable for canning, though it is rather large for this purpose.

Lincoln. — Early, dark purple, of large size and very fine quality; fruited but two years in the station orchards, but it seems very promising.

Fellemberg. — This seems identical with a variety that we have had growing for nearly thirty years under the name of the German prune. It is a regular biennial bearer, but never produces large crops. The fruit is of medium to large size, tapering at both ends. It is of deep purple color, a perfect freestone and of very good quality. Its great value lies in its long keeping and its fine canning qualities.

The Japanese plums, from their rapid growth, great productiveness, early bearing and attractiveness, are being quite largely planted in nearly all sections of the country, and promise to be of considerable value to our fruit growers who do not succeed in growing the domestic varieties. The trees seem to be a little less subject to the black knot and the brown rot, but more subject to the shot-hole fungus, and are often seriously injured by the use of the copper solution and the arsenites. The fruit is attractive, and meets a ready sale; but whether the demand will be large enough to keep up with the increased planting that is going on, time only can determine. All of the varieties of reported value have been planted in the station orchard, forty-eight in all, many of which will fruit next summer for the first time, unless the fruit buds are destroyed by the cold winter weather. In some cases these varieties are attacked by some disease similar to the peach yellows. Of the varieties that have been tested for several years in various sections of the country, the Abundance, Burbank, Red June and Satsuma have proved satisfactory. Of the newer varieties that are of very fine quality the Wickson, Hale and October Purple may be mentioned.

The Satsuma has not ripened here so as to be of much value for table use, but from the deep-red color of its flesh it is especially valuable for canning. It seems to be weak in self-fertilizing qualities, and needs to be planted among other varieties for the best results in pollination.

Cherries.

The crop of cherries in the station orchard would have been unusually large but for the extremely hot and moist weather at the time of ripening, which caused the fruit to rot badly. The trees had been regularly sprayed with Bordeaux up to the time when it would disfigure the fruit, but there was not a sufficient quantity of the copper from this to spread over the rapidly growing leaves and fruit. From results obtained here and from reports received from other stations, it is probable that spraying thoroughly *immediately* after each rain, as the fruit begins to color, with the copper solution (four ounces of copper sulphate to fifty gallons of water), would largely prevent this loss. It is urged that the coming season those engaged in growing cherries should try this treatment. It must be borne in mind that the application should be made very soon after the rain ceases, as the spores of the brown rot germinate very quickly when placed in moisture, and it is to prevent this germination that the application is made. Heavy rains, especially if soon followed by dry weather, need be little feared, as they tend to wash the spores off the plants, though some may gain a lodgement in the axils of the leaves or in the calyx of the fruit or other places. The varieties most satisfactory were Governor Wood, Napoleon, Black Tartarian and Early Richmond.

Grapes.

Perhaps upon no fruit crop grown in New England is the certainty of protection by spraying so great as with the grape crop, when properly done, and upon which insecticides and fungicides are so easily and cheaply applied. Campbell's Early, the only new variety fruiting that stands out as decidedly promising, produced fruit on several young vines. The growth of vine was satisfactory, the foliage free from disease, the fruit beautiful in appearance and of good quality. The compactness of bunch and firmness of berry will make it a good shipping grape, and, if it does not develop a tendency to disease, it will be a valuable addition to the few varieties that can be profitably grown in New England. It ripens as early or perhaps a little before Moore's Early, and is much superior in quality. The varieties recommended for this section are Winchell or Green Mountain, Worden and Delaware.

Currants.

There is scarcely another fruit the merits of whose new varieties it is so difficult to decide as the currant, because of its great variation in size and productiveness under different conditions. All the new varieties of any prominence have been planted in the station plots, and those that stand out prominently as possessing merit are the Pomona, Wilder and the Red Cross; and, after three years fruiting, their value seems to be in the order given. The Pomona may be mentioned as of especial value, because of its superior quality. We have no records, however, to show that any of the above varieties will be more valuable for general cultivation than Fay's Prolific or the Cherry.

Blackberries.

All of the prominent new varieties have been added to the list under trial, but none have thus far shown themselves to be more valuable than the best older sorts, — the Agawam, Snyder and Taylor's Prolific. On heavy soils, where the growth is large and furnishes an abundant soil cover, thus keeping the ground cool, the first-named variety proves very satisfactory; but when grown on light land it is of much less value.

The Eldorado continues to do well, and compares favorably with the above-mentioned varieties; but whether it will prove more valuable than any other, can only be determined in large plantation.

Raspberries.

With the red raspberry there has been little or no progress made in improved varieties. The Loudon, which, from its stocky growth, hardiness and fruit of good size, color and quality, seemed very promising, has the past season shown a tendency to mildew of the leaves and young growing canes. If this becomes general, it will greatly reduce its value. The seedlings produced from the seeds of the Shaffer, and referred to in a previous bulletin, have again fruited, and many of them show decided merit, some producing fruit of a bright scarlet color upon plants that propagate only from the tip of the cane, as does the Shaffer; while others produce fruit of the Shaffer type that propagate from suckers, like the common red raspberry.

Strawberries.

The past season was favorable for a large crop of fruit, but the extremely wet weather at the time of ripening caused much loss by rotting. The named varieties were planted in plots of twenty-five plants each, while the most promising of these are planted each season in rows under field culture. Of the varieties in plots (soil medium heavy loam), the Brandywine, Gandy Bell, Glen Mary, Sample and Howard's No. 14 gave the best results. Of those grown under field culture, on light land, the Clyde, Cumberland, Glen Mary, Howard's Nos. 36 and 41 gave the best results.

New Fruits.

Several new species of raspberries, the strawberry-raspberry, Logan-berry, Salmon-berry, May-berry, etc., have been planted, some of which have fruited, but only two seem to possess any merit for this climate. The strawberry-raspberry is an herbaceous perennial, the top of which dies to the ground in the winter, but is followed by numerous shoots in the spring from underground stems, that bear most beautiful wine-colored fruit in abundance. This fruit is of a peculiar, insipid, though not unpleasant flavor, and may be the origin of new varieties with a more decidedly pleasant taste. Should such varieties be produced, and a system of cultivation be worked out by which a reasonably certain crop can be secured, it may prove a valuable addition to our list of hardy fruits.

The Logan berry resembles the common dewberry or running blackberry in habit of growth and form of fruit; but the latter is rather larger, and of a dark-red or mahogany color. It possesses a pleasant flavor, but the same obstacle to its general cultivation is met as with the dewberry, — that it is difficult to devise a method of cultivation and training that will give a large crop of fruit every year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. Lindsey.

Assistants, E. B. Holland, F. W. Mossman, B. K. Jones, P. H. Smith, Jr.

Part I. — Laboratory Work.

Outline of Year's Work.

Part II. — Feeding Experiments and Dairy Studies.

Part I.

Extent of Chemical Work.

The laboratory work connected with this department has been much increased during the past year. We have received for examination 159 samples of water, 228 samples of milk, 17 samples of butter, 4 samples of oleomargarine and 81 samples of feed stuffs. The work in connection with this and other divisions of the Station has consisted of the analysis of 394 samples of milk, 26 samples of butter, 292 samples of fodders and 11 miscellaneous samples. In addition to the above, we have collected 754 samples of feed stuffs under the provisions of the feed law, of which 663 samples have been examined. This makes a total of 1,875 substances analyzed, as against 1,147 in 1897. There have also been carried on for the Association of Official Agricultural Chemists, investigations relative to the best methods for the determination of potash, and of the different ingredients in cattle foods, as well as a study of the most desirable methods to be employed in the estimation of sugar. It is hardly possible to express numerically the extent of this work.

Character of Chemical Work.

Water. — We have followed the same general line of investigation as in former years, in the examination of waters sent by farmers and others.

Whenever possible printed instructions are sent for sampling and sending the water. In making a report to the party, a printed form is used. Upon the form there is explained the meaning of the terms used, so that every one will have at least a general idea of what the analytical results are meant to convey.

Those sending the samples have been advised promptly whether in our judgment the water was suitable for drinking and general domestic purposes. Whenever necessary, suggestions have been offered with the hope of improving the family supply. We again caution everyone who depends upon wells and springs for their drinking water to have all sink drains, etc., remote from the well, and to keep the ground in the vicinity free from objectionable matter. Lead pipes should never be used in drawing water from wells.

Milk. — Some of the milk sent to the station has been from farmers who ship their milk to the Boston market, and having been notified by the contractors that their article was below the legal standard, wished to ascertain if such was the fact, and if so, what could be done for its improvement. To such we have given the same advice as appeared in our last annual report, to which interested parties are referred.

Many farmers are now sending occasional samples of milk, cream and skim-milk to the station, to ascertain the amount of butter fat contained in them. These producers sell their milk to creameries, and they are desirous of knowing its quality for butter production. This is a very encouraging sign, for it shows that the farmer really wishes to know the butter-producing capacity of his cows, and the efficiency of his separator, or Cooley creamer, in removing the fat from his milk. To all who desire, printed information is given, stating how to ascertain the yearly butter capacity of dairy cows.

Much of the milk and butter analyzed in connection with our own experiments has been studied with a great deal of care. We have estimated the water, solids, fat, casein, milk sugar, and ash in a large number of samples. We have also made a very thorough examination of 26 samples of butter fat produced by cows employed in connection with our feeding experiments. There have been determined in duplicates or triplicates, volatile acids, specific gravity, melting point, and the iodine number.

Cattle Feeds. — Our feed law has now been in operation about one and one-half years. We have made frequent inspections covering the entire State, and have published two especially prepared bulletins giving the results of our investigations. We have endeavored to make these bulletins as practical as possible, and judging from the way in which the bulletins are received, it is believed that we have in a measure succeeded. During the spring of 1898 a considerable quantity of adulterated cotton-seed meal was found in various sections of the State. Printed slips of warning were immediately sent to 100 newspapers in the State, and a concise circular was also mailed to every grain dealer, cautioning against its purchase. While meal of this character generally has a darker appearance than the prime article, samples of inferior meal have recently been found having quite a bright yellow color. A number of reputable manufacturers now print a guaranty upon every package, and purchasers are strongly advised to buy only the guaranteed article. The effect of the feed law has been to call the attention of all manufacturers to the necessity of branding their products, and having them run as even as possible in composition. Many of the more reputable manufacturers are now placing a guaranty upon their feeds, and it is hoped others will soon follow.

Many new feeds are constantly being offered for sale in our markets. A number have appeared during the year 1898. Our object is to secure samples of these materials promptly, and ascertain their feeding and comparative commercial values. For detailed information the reader is referred to Bulletins 53 and 56.

Other Chemical Work. — The analyses of feed stuffs and manures in connection with the numerous digestion experiments carried on by this division, involves a considerable amount of time and effort, but because of this work we are enabled to state with a reasonable degree of accuracy the feeding and commercial values of the concentrated feeds sold upon the market, and of the coarse feeds produced upon our farms.

It is the object of this division to assist the Association of Official Agricultural Chemists as much as possible in perfecting methods of chemical analyses, and in finding out methods for the estimation of the quantity and nutritive value of several of the newer carbohydrates. We spend whatever time can be had during each year in working along these lines, believing it will be productive of much good in the future. During the past year we have given attention to the estimation of pentosans, starch and sugar in agricultural plants.

The chemical work received from the agricultural division has very much increased during the past year. This work consists of the determination of dry matter in a large number of plants, the estimation of starch in potatoes, the analyses of feed stuffs used in poultry experiments, and in general fodder analyses. This increased work is now severely taxing the resources of our chemical force.

Part II.

A. Cleveland Flax Meal *v.* Old-process Linseed Meal for Early Lambs.

Object of the Experiment.

It has recently been claimed, by parties who grow early lambs for market, that the so-called new-process linseed meal (Cleveland flax meal) exerted an injurious effect upon the young lamb. Some claim that this meal did not favor growth, and others that it was the cause of frequent sudden deaths. On the other hand, it was stated that the old-process meal did not have these injurious effects, but favored rapid growth and fattening. The station was asked to throw some light on the subject, and conducted the following experiment in the winter and early spring of 1898.

The Experiment.

Six grade Southdown ewes were brought to the station barn the first week in February, and each placed in a separate pen six feet wide by fifteen feet long. The pens were separated by stout wire netting, thus enabling the animals to see each other. The ewes were all in fair condition, and in about two weeks' time began to drop their lambs. Each lamb was weighed five days after being dropped.

Daily Feed for the Ewes after Lambing. — Two pounds corn ensilage, rowen *ad libitum*, 1 pound grain mixture. The grain mixture* was gradually increased until each ewe received 2½ pounds daily. This grain feed was kept up as long as the ewes would take it, and was then gradually reduced. The grain mixture, as will be noticed, contained about one-third of one of the two kinds of linseed meal.

Daily Feed for the Lambs. — The pens were so arranged that the lambs gained access to a separate compartment, containing a mixture of grains. They soon learned to go in as soon as the feed was placed in the troughs. It was our aim

* The grain mixture consisted of 7.5 pounds of old-process linseed or flax meal, 7.5 pounds of bran, 5 pounds corn meal and 5 pounds gluten feed.

to feed them what they would eat daily: grain mixture No. 1, 7.5 pounds flax meal or old-process linseed meal, 7.5 pounds bran, 10 pounds corn meal.

After feeding this mixture for about two weeks, a second was fed, as follows: 10 pounds flax meal or old-process linseed meal, 5 pounds bran, 5 pounds corn meal.

When the lambs each reached 40 pounds in weight, the mixture was again changed to: one-third flax meal or old-process linseed meal, one-third bran, one-third corn meal.

It was our object to give the lambs as much of each of the two linseed meals as they would stand, and keep in a healthy, growing condition.

Care of the Lambs. — The lambs were kept in the pens with the ewes. As the season advanced, they were allowed the run of a large yard in the warmer part of sunny days.

Record of Growth.

Flax Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 8, . .	March 3,	May 5,	62	15.25	67.00	51.75	.83
Lamb No. 6, . .	March 1,	May 18,	78	10.25	57.50	47.25	.62
Lamb No. 7, . .	March 1,	May 25,	85	10.50	53.00	42.50	.50
Lamb No. 1, . .	February 25,	May 18,	82	9.50	47.50	38.00	.46
Lamb No. 2, . .	February 25,	May 25,	89	9.25	41.00	31.75	.36
Average, . .	-	-	79	10.95	53.20	42.25	.54

Old-process Linseed Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 5, . .	February 25,	April 29,	63	11.75	52.25	40.50	.64
Lamb No. 3, . .	February 25,	May 18,	82	11.00	50.00	39.00	.48
Lamb No. 4, . .	February 25,	May 25,	89	8.75	44.50	35.75	.40
Lamb No. 9, . .	March 19,	June 1,	74	10.25	52.25	42.00	.57
Lamb No. 10, . .	March 19,	June 1,	74	9.00	51.00	42.00	.57
Average, . .	-	-	76	10.15	50.00	39.85	.53

Note. — Lambs 6 and 7, 1 and 2, 3 and 4, 9 and 10, were twins.

The lambs were shipped to Ira C. Lowe of Greenfield, Mass., who slaughtered them, and reported on their condition. He had no knowledge as to which lambs were fed the flax meal and which lambs were fed the old-process linseed meal ration. Lamb No. 8 was reported to be of extra quaility, Lamb No. 5 next in quality to No. 8, and the others of fair quality only. Looking at the average figures in the above tables, it will be seen that each lot of five lambs showed the *same daily gain*. Mr. Lowe noticed no particular advantage in favor of either lot.

Results of the Experiment.

As a result of our observations, we conclude: —

That the flax meal had no injurious effect either upon the growth or dressed appearance of the lambs, and that both sets of lambs produced the same average daily growth, and were both in the same average condition when slaughtered.

Remarks and Suggestions.

It is well known to all growers of early lambs, that in order to secure a rapid growth of the lamb, the ewe should be thrifty, and a good milker. A liberal feeding will aid in keeping up a continuous flow of milk. The early growth of the lamb will depend very much on the constitution it inherits, and upon its success in obtaining a large supply of milk. Easily digested nitrogenous feed stuffs will unquestionably assist in producing quick growth, but they are secondary to the milk supply. This is quite forcibly illustrated in case of our experiments as described above. Lamb No. 8 was single, and its mother was an excellent milker. The lamb was above the average in size and vigor when dropped. He grew rapidly, showing .83 of a pound gain per day. It was noticed that this lamb did not consume very large amounts of grain, although he had a constant opportunity. He derived the larger part of the food necessary for his growth from his mother. Lamb No. 5 was also a single lamb. He made a very good growth, but the ewe was not as good a milker as the previous one. This lamb took more grain than did No. 8, but was not able to make as rapid growth. The other lambs were twins. They did not grow as rapidly as did the single lambs, because of the lack of milk, although they ate quite freely of the grain mixtures. Lambs Nos. 6 and 7 came from a good milker, and they were also quite vigorous and hearty eaters.

In addition to inherited constitution and plenty of milk, it is very essential, in order to secure rapidity of growth, that early lambs should be housed in a warm, dry barn, and have a maximum amount of sunlight from a southern exposure.

B. Corn Meal *v.* Hominy Meal, and Corn Meal *v.* Cerealine Feed for Growing Pigs.

Experiment I. — Corn meal *v.* hominy meal.
Experiment II. — Corn meal *v.* cerealine feed.
Experiment III. — Corn meal *v.* cerealine feed.

Objects of the Experiments.

Skim-milk is a very valuable feed for growing pigs. It is a digestible, nitrogenous feed stuff. Of itself it is not a complete food, being deficient in solid matter as well as in carbohydrates (starchy material). In order to make a complete food, carbohydrate feeds are necessary to properly balance the daily ration. A combination of skim-milk and corn meal (1 quart milk and from 3 to 6 ounces of meal) has been found to make a most excellent feed for rapid growth. The object of the above-mentioned experiments was to get at the feeding values of hominy meal and cerealine feed, when compared with corn meal, for this purpose.

What Hominy Meal is. — Hominy meal consists of the hulls, germ and some of the starch and gluten of the corn, ground together. This separation is said to be brought about solely by the aid of machinery. The hard, flinty part of the corn is the hominy, which is used as a human food.

What Cerealine Feed is. — This feed consists also of the hull and a portion of the starch of the corn. It contains rather less of the starch than does the hominy meal. It is the by-product resulting from the preparation of the breakfast preparation known as cerealine flakes. It is very coarse looking, and appears much like unground corn hulls.

Results of Experiments.

1. Hominy meal produced 5 to 7 per cent. more growth, when fed to pigs in connection with skim-milk, than did corn meal. This difference was probably due to the dryer condition of the hominy meal, and nearly disappears when the meals are compared on a basis of dry matter they contained.

2. In view of the fact that Pig IV. was thrown out of the experiment, we should hesitate to say that the hominy meal had proved itself in any degree superior to the corn meal. This experiment would seem to indicate, however, that pound for pound, as found in the market, the hominy meal is at least fully as valuable as the corn meal.

3. In the two experiments with cerealine feed and corn meal, the corn meal produced 5 per cent. more growth than did the cerealine feed. Corn meal constituted but 62 per cent. of the dry matter of the ration; and, if 62 per cent. of dry matter of the ration in the form of corn meal produced a gain of 5 per cent., 100 per cent. of corn meal — *e. g.*, its full effect — would show an 8 per cent. gain.

4. We think we are justified in saying that corn meal is from 5 to possibly 10 per cent. more valuable than cerealine feed for use in connection with skim-milk for growing pigs.

5. Cerealine feed might prove equal to corn meal as a feed for milch cows, as digestion experiments with sheep have shown it to contain as much digestible matter as corn meal. It is very probable that pigs are not able to digest the hulls of the corn as well as other animals.

6. Because of the important part played by the individuality of the animal, we are frank to confess that a larger number of pigs would be desirable in conducting experiments of this kind. We feel confident, however, that these experiments give a fairly accurate representation of the comparative values of the several feed stuffs.

Experiment I. — Corn Meal v. Hominy Meal.

Nov. 23, 1896, to March 1, 1897 (98 Days). — Eight grade Chester White pigs, all of the same litter, were purchased in October. They were first fed skim-milk alone, and finally divided into two lots, and corn or hominy meal added to the skim-milk diet. Pigs Nos. I. and II. were together in one pen, and so were pigs Nos. VII. and VIII.; the others were in separate pens. Pig IV. was taken sick during the experiment, and his record is not considered. Each pig was allowed from 7 to 10 quarts of skim-milk daily, and from 3 to 6 ounces of grain for each quart of milk, the quantity depending on the appetite and stage of growth of the animals. As the pigs advanced in age and growth, the quantity of grain was increased, thus furnishing an increased food supply and an increasing amount of carbohydrates.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. V.,	884.00	1,927.12	183.08	255.44	223.25
Pig No. VI.,	883.00	1,924.94	182.37	255.44	223.25
Pigs Nos. VII. and VIII.,	1,766.00	3,849.88	365.74	510.88	446.50
Totals,	3,533.00	7,701.94	731.69	1,021.76	893.00
Averages,	883.25	1,925.49	182.92	255.44	223.25

Hominy Meal Lot.

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Hominy Meal (Pounds).	Dry Matter (Pounds).
Pigs Nos. I. and II.,	1,768.00	3,854.24	366.15	255.06	470.23
Pig No. III.,	883.00	1,924.94	182.37	255.44	235.45
Totals,	2,651.00	5,779.18	549.02	765.56	706.69
Averages,	883.67	1,926.39	183.01	255.19	235.23

The above tables show that each lot of pigs consumed identical amounts of skim-milk, and very nearly equal amounts of grain. The hominy meal lot ate about 12 pounds more of dry grain per pig, than did the corn meal lot.

TOTAL GAIN IN LIVE WEIGHT.

Corn Meal Lot.

NUMBER OF PIG.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. V.,	54.50	184.25	129.75	1.32
Pig No. VI.,	58.25	167.00	130.25	1.33
Pigs Nos. VII. and VIII.,	109.25	188.50 185.25	243.00	2.48
Totals,	222.00	725.00	503.00	5.13
Averages,	55.50	181.25	125.75	1.28

Hominy Meal Lot.

Pigs Nos. I. and II.,	115.50	387.25	271.75	2.77
Pig No. III.,	57.75	196.00	138.25	1.41
Totals,	173.25	583.25	410.00	4.18
Averages,	57.75	194.42	136.66	1.39

One notes a very slight difference in favor of the hominy fed lot, this being caused perhaps by the slightly increased amount of actual dry matter found in the hominy meal.

By referring to the table, it will be noticed that each pig received 223.25 pounds of perfectly dry corn meal and 235.23 pounds of perfectly dry hominy meal.

Total Gain in Dressed Weight.

Corn Meal Lot.

Number of Pig.	Dressed Weight at End of Experiment (Pounds).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Total Gain in Dressed Weight (Pounds).	Loss in Weight in Dressing (Pounds).
Pig No. V., . . .	150.50	44.52	105.98	18.31
Pig No. VI., . . .	154.25	47.67	106.58	18.17
Pigs Nos. VII. and VIII.,	287.25	89.09	198.16	18.45
Totals, ...	592.00	181.28	410.72	54.83
Averages, . . .	148.00	45.32	102.68	18.28

Hominy Meal Lot.

Number of Pig.	Dressed Weight at End of Experiment (Pounds).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Total Gain in Dressed Weight (Pounds).	Loss in Weight in Dressing (Pounds).
Pigs Nos. I. and II., . .	306.00	91.25	214.75	20.89
Pig No. III., . . .	152.00	44.79	107.21	22.45
Totals, ...	458.00	136.04	321.96	43.34
Averages, . . .	152.66	45.35	107.32	21.67

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. V., ...	3.13	3.84
Pig No. VI., ...	3.12	3.81
Pigs Nos. VII. and VIII., ...	3.34	4.09
Averages, ...	3.20	3.91

Hominy Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pigs Nos. I. and II., ...	3.08	3.89
Pig No. III., ...	3.03	3.90
Averages, ...	3.06	3.89

The very slight difference between the gains in the two lots is within the limit of error.

Experiment II. — Corn Meal v. Cerealine Feed.

April 12 to July 26, 1897 (106 Days). — The six pigs used in this experiment were grade Chester Whites, about five weeks old when purchased, March 2. They were brought into separate pens April 1, and the experiment began April 12. Each pig was fed 6 to 9 quarts of skim-milk daily, together with 3 ounces of grain for each quart of milk. The amount of grain was gradually increased as the animal demanded it, until some 4 pounds daily were fed. The milk never exceeded 9 quarts per day.

At the beginning of the experiment the animals were receiving 1 part protein to 3 parts carbohydrates. The ration was gradually widened, until towards the close of the experiment the nutritive ratio was as 1 to 7. The corn meal heated during the latter part of the experiment, and became somewhat musty.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. I., ...	738.00	1,608.84	152.84	243.63	204.98
Pig No. II., ...	738.00	1,608.84	152.84	243.63	204.98
Pig No. III., ...	738.00	1,608.84	152.84	243.63	204.98
Totals, ...	2,214.00	4,826.52	458.52	730.89	614.94
Averages, . . .	738.00	1,608.84	152.84	243.63	204.98

Cerealine Feed Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. IV., ...	738.00	1,608.84	152.84	243.63	214.39
Pig No. V., ...	738.00	1,608.84	152.84	243.63	214.39
Pig No. VI., ...	738.00	1,608.84	152.84	243.63	214.39
Totals, ...	2,214.00	4,826.52	458.52	730.89	643.17
Averages, . . .	738.00	1,608.84	152.84	243.63	214.39

Some 10 pounds more dry cerealine feed were consumed per pig than corn meal during the experiment, due to the dryer condition of the cerealine feed when fed.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I., ...	51.25	188.00	136.74	1.29
Pig No. II., ...	48.50	184.00	135.50	1.28
Pig No. III., ...	43.25	184.25	141.00	1.33
Totals, ...	143.00	556.25	413.25	3.90
Averages, ...	47.67	185.42	137.75	1.30

Cerealine Feed Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV., ...	44.00	175.50	131.50	1.24
Pig No. V., ...	41.00	170.50	129.50	1.22
Pig No. VI., ...	49.25	186.00	136.75	1.29
Totals, ...	134.25	532.00	397.75	3.75
Averages, ...	44.75	177.33	132.58	1.25

A slight gain in favor of the corn meal lot is noted.

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I., ...	2.62	3.28
Pig No. II., ...	2.64	3.30
Pig No. III., ...	2.54	3.17
Averages, ...	2.60	3.25

Cerealine Feed Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV., ...	2.79	3.49
Pig No. V., ...	2.84	3.54
Pig No. VI., ...	2.69	3.37
Averages, ...	2.77	3.46

The above figures show a slight difference in favor of the corn meal, rather less dry matter in corn meal being required to make a pound of growth than in cerealine feed.

Experiment III. — Corn Meal v. Cerealine Feed.

Oct. 25 to Jan. 10, 1898 (78 Days). — The six pigs employed in this experiment were a cross between the Poland-China and the Chester White. They were received early in September, when five weeks old, and allowed the run of a large pen out of doors until October 20, when they were placed in separate pens in the feeding barn, and divided as equally as possible into two lots. They were in a very vigorous condition. In this experiment the cerealine feed heated towards the close of the experiment. It was shovelled over and dried at once when this condition was observed, and the experiment continued. The pigs ate it with seeming relish at all times.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. IV., ...	468.00	1,020.24	96.92	226.50	197.06
Pig No. V., ...	468.00	1,020.24	96.92	226.50	197.06
Pig No. VI., ...	468.00	1,020.24	96.92	226.50	197.06
Totals, ...	1,404.00	3,060.72	290.76	679.50	591.18
Averages, . . .	468.00	1,020.24	96.92	226.50	197.06

Cerealine Feed Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. I., ...	468.00	1,020.24	96.92	226.50	201.59
Pig No. II., ...	468.00	1,020.24	96.92	222.50	198.03
Pig No. III., ...	468.00	1,020.24	96.92	226.50	201.59
Averages, . . .	468.00	1,020.24	96.92	225.20	200.40

The amount of feed consumed by the two lots is practically identical.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV.,	68.50	172.50	104.00	1.33
Pig No. V.,	67.75	172.00	104.25	1.34
Pig No. VI.,	66.75	173.00	106.25	1.36
Totals,	203.00	517.50	314.50	4.03
Averages,	67.67	172.50	104.83	1.34

Cerealine Feed Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I.,	73.75	169.00	95.25	1.22
Pig No. II.,	57.25	150.00	92.75	1.19
Pig No. III.,	68.75	174.00	105.25	1.35
Totals,	199.75	593.00	293.25	3.76
Averages,	66.58	164.33	97.75	1.25

Each pig in the corn meal lot shows an average gain of 7 pounds over the cerealine feed pigs. This might partly be accounted for by reason of the poor condition of the cerealine feed, already mentioned.

Dry Matter required to produce One Pound Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV.,	2.83	3.53
Pig No. V.,	2.82	3.52
Pig No. VI.,	2.77	3.42
Averages,	2.81	3.49

Cerealine Feed Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I.,	3.13	3.91
Pig No. II.,	3.18	3.98
Pig No. III.,	2.84	3.55
Averages,	3.05	3.81

The dry matter required to produce a pound of gain confirms the results given in the tables under gain in live weight, and shows that in this experiment a pound of live weight was produced by ¼ of a pound less of absolutely dry corn meal than of dry cerealine feed. The conclusions from these three experiments have already been given on page 28.

Composition of Feeds (used in Three Feeding Experiments).

Separate Ingredients of Feeds.	Average Skim-milk, All Experiments (per Cent.).	Experiment I.		Experiment II.			Experiment III.	
		Corn Meal (per Cent.).	Hominy Meal (per Cent.).	Corn Meal, I. (per Cent.).	Corn Meal, II. (per Cent.).	Cerealine Feed (per Cent.).	Corn Meal (per Cent.).	Cerealine Feed (per Cent.).
Water, . .	90.50	12.63	7.82	20.00	14.00	12.00	13.00	11.00
Protein, . .	-	8.78	10.59	8.86	9.03	9.55	9.64	10.96
Fat, . . .	-	4.08	8.50	2.18	2.15	6.60	3.59	6.30
Extract matter, .	-	71.73	65.46	65.80	71.68	65.23	70.80	64.55
Fibre, . . .	-	1.42	4.11	1.82	1.81	4.40	1.70	4.36
Ash, . . .	-	1.36	3.52	1.34	1.33	2.22	1.27	2.83
Totals, . .	-	100.00	100.00	100.00	100.00	100.00	100.00	100.00

C. The Cost of Pork Production.

In a section of our State the cream from the milk produced upon the farm is sold to the creamery, and the skim-milk is either fed to pigs or calves. A large number of experiments have been made at this station with growing pigs. The pigs averaged from 37 pounds in weight at the beginning of the experiments to 183 pounds when slaughtered. The daily rations have been essentially as follows: —

I. From 5 to 7 quarts of milk per day; and, beginning with 3 ounces of corn meal to each quart of milk, the grain has been gradually increased to satisfy the appetite of the animal.

II. About the same quantity of milk, and, instead of the corn meal, other carbohydrate foods, such as ground rye, wheat, hominy meal, cerealine feed and oat feed, to satisfy appetites.

III. About the same quantity of milk, together with 3 to 6 ounces of corn meal to each quart of milk, and a mixture of one-third wheat bran, one-third gluten meal and one-third corn meal, to satisfy appetites.

More exact statements of rations will be found farther on. We rarely had more than from 5 to 7 quarts of milk daily for each pig. The animals did well with this amount of milk; if they did not secure this quantity, their growth was noticeably slower.

Explanation of Tables.

As a result of these various experiments, we have endeavored to ascertain: —

1. The price that skim-milk has returned per quart.

2. The cost of feed required to produce *a pound* of *live* or *dressed weight*, taking the various grains at a reasonable range of market prices, and allowing either $\frac{1}{4}$ or $\frac{1}{2}$ cent per quart for the milk.

In tables I., II. and III. will be found the results where milk and corn meal have been fed.

Tables IV., V. and VI. will show the results where milk and other starchy (carbohydrate) feeds have been substituted for the corn meal, such as hominy or cerealine feeds, rye and wheat meals ("grain").

Tables VII., VIII. and IX. show the results where milk and corn meal were fed, and, in addition, wheat bran, gluten meal, etc. ("other grains").

Tables X. and XI. show the average of all the preceding, being the results with 140 pigs, weighing 37 pounds at the beginning, and 183 pounds at the close of the experiments.

TABLE I. — *Milk and Corn Meal.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 21 pigs,	16,421	35,797.78
Total corn meal consumed by 21 pigs,	-	5,531.10
Live weight, actually gained,	-	3,012.25
Dressed weight, calculated,	-	2,409.80

TABLE II. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH CORN MEAL AT $15 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.48	.63	.77	.44	.58	.73	.39	.54	.69
Per 100 pounds (cents),	22.02	28.90	35.37	20.19	26.61	33.48	17.89	24.77	31.19

TABLE III. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 per ton, and milk at ¼ cent per quart,	2.74	3.44
With corn meal at $15 per ton, and milk at ½ cent per quart,	4.11	5.13
With corn meal at $17.50 per ton, and milk at ¼ cent per quart,	2.98	3.72
With corn meal at $17.50 per ton, and milk at ½ cent per quart,	4.33	5.41
With corn meal at $20 per ton, and milk at ¼ cent per quart,	3.21	4.02
With corn meal at $20 per ton, and milk at ½ cent per quart,	4.59	5.71

TABLE IV. — *Milk and Different Starchy Feeds.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 22 pigs, ...	13,153	28,630
Total "grain" consumed by 22 pigs, ...	-	5,135
Live weight, actually gained, ...	-	2,597
Dressed weight, calculated, ...	-	2,078

TABLE V. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH "GRAIN" AT $15 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound)
Per quart (cents), .	.50	.65	.81	.45	.60	.76	.40	.56	.87
Per 100 pounds (cents),	22.90	30.10	37.10	20.60	27.80	35.10	18.35	25.69	39.91

TABLE VI. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With "grain" at $15 per ton, and skim-milk at ¼ cent per quart, ...	2.75	3.43
With "grain" at $15 per ton, and skim-milk at ½ cent per quart, ...	4.01	5.01
With "grain" at $17.50 per ton, and skim-milk at ¼ cent per quart, ...	3.00	3.75
With "grain" at $17.50 per ton, and skim-milk at ½ cent per quart, ...	4.26	5.32
With "grain" at $20 per ton, and skim-milk at ¼ cent per quart, ...	3.24	4.05
With "grain" at $20 per ton, and skim-milk at ½ cent per quart, ...	4.51	5.63

TABLE VII. — *Milk, Corn Meal, Bran, Gluten Meal, etc.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 97 pigs, ...	62,319	135,855
Total corn meal consumed by 97 pigs, ...	-	21,602
Total "other grains" consumed by 97 pigs, ...	-	12,663
Live weight actually gained, ...	-	15,080
Dressed weight calculated, ...	-	12,064

TABLE VIII. — *Price obtained for Skim-milk.*

PRICE OBTAINED FOR SKIM-MILK.	WITH CORN MEAL AT $15 PER TON, "OTHER GRAINS" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $17.50 PER TON, "OTHER GRAINS" AT $20 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $20 PER TON, "OTHER GRAINS" AT $22.50 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents),	.53	.72	.92	.45	.65	.85	.39	.59	.78
Per 100 pounds (cents),	24.30	33.20	42.10	21.20	30.00	39.00	18.00	27.00	36.00

TABLE IX. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 "other grains" at $17.50 and milk at ¼ cent per quart,	2.84	3.55
With corn meal at $15 "other grains" at $17.50 and milk at ½ cent per quart,	3.87	4.84
With corn meal at $17.50 "other grains" at $20 and milk at ¼ cent per quart,	3.13	3.90
With corn meal at $17.50 "other grains" at $20 and milk at ½ cent per quart,	4.16	5.20
With corn meal at $20 "other grains" at $22.50 and milk at ¼ cent per quart,	3.41	4.26
With corn meal at $20 "other grains" at $22.50 and milk at ½ cent per quart,	4.44	5.55

TABLE X. — *Price obtained for Skim-milk (All Experiments).*

AVERAGE PRICE OBTAINED FOR SKIM-MILK.	WITH CORN MEAL AND OTHER STARCHY FOODS AT $15 PER TON, "OTHER GRAINS" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AND OTHER STARCHY FOODS AT $17.50 PER TON, "OTHER GRAINS" AT $20 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AND OTHER STARCHY FOODS AT $20 PER TON, "OTHER GRAINS" AT $22.50 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents),	.50	.67	.83	.45	.61	.78	.39	.56	.78
Per 100 pounds (cents),	23.07	30.73	38.19	20.66	28.14	35.86	18.08	25.82	35.70

TABLE XI. — *Average Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 "other grains" at $17.50, milk at ¼ cent per quart,	2.78	3.47
With corn meal at $15 "other grains" at $17.50, milk at ½ cent per quart,	4.00	4.99
With corn meal at $17.50 "other grains" at $20, milk at ¼ cent per quart,	3.04	3.79
With corn meal at $17.50 "other grains" at $20, milk at ½ cent per quart,	4.25	5.31
With corn meal at $20 "other grains" at $22 50, milk at ¼ cent per quart,	3.63	4.53
With corn meal at $20 "other grains" at $22.50, milk at ½ cent per quart,	4.51	5.63

D. RATIONS FOR GROWING PIGS.

RATION No. I. — *With Unlimited Supply of Milk.*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	3 ounces of corn meal * to each quart of milk.
60 to 100 pounds,	6 ounces of corn meal to each quart of milk.
100 to 180 pounds,	8 ounces of corn meal to each quart of milk.

RATION No. II. — *With Limited Supply of Milk (5 to 6 quarts per Pig daily).*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	3 ounces of corn meal * to each quart of milk, and then gradually increase corn meal to satisfy appetites.
60 to 100 pounds,	
100 to 180 pounds,	

* Wheat, rye or hominy meals can be substituted for corn meal.

RATION No. III.

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	Milk at disposal, plus mixture of one-third corn meal, one-third wheat bran and one-third gluten meal, to satisfy appetites.
60 to 100 pounds,	Milk at disposal, plus mixture of one-half corn meal, one-quarter wheat bran and one-quarter gluten meal, to satisfy appetites.
100 to 180 pounds,	Milk at disposal, plus mixture of two-thirds corn meal, one-sixth wheat bran and one-sixth gluten meal, to satisfy appetites.

RATION NO. IV.*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds, .	3 ounces of corn meal to each quart of milk, and 4 ounces of gluten feed as a substitute for quart of milk.
60 to 100 pounds, .	Milk at disposal, and mixture of one-half corn meal and one-half gluten feed, to satisfy appetites.
100 to 180 pounds, .	Milk at disposal, and mixture of two-thirds corn meal and one-third gluten feed, to satisfy appetites.

* This ration is preferable to Ration No. II.

E. EXPERIMENTS WITH SALT HAY.

The extensive series of experiments carried on to ascertain the nutritive value of different kinds of salt hay were completed and the experiments and results published in Bulletin No. 50, in January, 1898, to which the reader is referred for all details.

F. EXPERIMENTS TO ASCERTAIN THE EFFECT OF DIFFERENT AMOUNTS OF PROTEIN UPON THE COST AND QUALITY OF MILK.

During the winter of 1897–98 two experiments, with twelve cows, were carried out, to investigate the effect of 1.50, 2 and 2.50 pounds of protein upon the cost and quality of milk. The total amount of digestible nutrients fed daily was the same in each case. Experiment I. extended over nine weeks and Experiment II. over four weeks. This work has not been published. About 5 per cent. more milk was produced on 2 pounds, and 10 per cent. more on 2½ pounds, of protein daily, than when the animals received 1^{1} pounds each. The quality of the milk was scarcely changed. The cost of the different rations will depend upon the cost of the several concentrated feeds. As the market has been for the past two years, milk produced by aid of the rations containing 2½ pounds of protein daily would cost rather less than that produced by 1½ or 2 pounds. The manure derived from the highest protein ration would be 10 per cent. more valuable, and the animals generally have a better appearance than when receiving but 1½ pounds per day. It is believed that a continuous feeding of 2 or 2½ pounds of protein daily tends, to some extent, to develop the milk-producing capacity of the cow. Animals that will not stand a reasonably generous feeding had better be consigned to the butcher. The writer is of the opinion that animals weighing from 800 to 1,000 pounds, producing from 10 to 15 quarts of milk per day, should receive about 2.5 pounds of digestible protein and 15 to 16 pounds of total nutrients daily. This is in accordance with Wolff's rations. When protein is costly, it might be advisable to reduce the amount to 2 pounds daily. The detailed records of these and other experiments along this line will be published later.

G. Digestion Experiments.

During the past three years there have been made about forty successful digestion experiments, mostly with the various concentrated feeds, to ascertain their value for feeding purposes. The details of the experiments have not been published. Some of the results (digestion coefficients) have been published in Bulletin No. 50, and in the annual reports for 1896 (page 135) and 1897 (page 84); others follow below. The results have been utilized in showing the nutritive value of a number of coarse fodders, and in preparing a key to the comparative values of concentrated feeds, as given in Bulletin No. 56 (page 23). It is hoped to publish the details of the experiments before long.

Digestion Coefficients resulting from Digestion Experiments.

Kind of Feed Stuff.	Number of Different Samples.	Number of Single Trials.	Dry Matter (per Cent.).	Protein (per Cent.).	Fat (per Cent.).	Extract (per Cent.).	Fibre (per Cent.).	Ash (per Cent.).
Hay (largely *Poa pratensis*),	1	6	62	61	50	63	65	46
Hay (largely *Poa pratensis*),	1	4	60	58	53	61	60	50
Average, both samples,	2	10	61	60	51	62	63	48
Hay of mixed grasses (late cut),	1	2	53	54	39	54	56	26
Hay of mixed grasses (late cut),	1	2	57	55	44	57	59	42
Barn-yard millet hay (late blossom),	1	3	57	64	46	52	62	63
Barn-yard millet (green, blossom),	1	2	74	68	64	76	74	66
Barn-yard millet (green, week later than above),	1	1	67	72	61	65	71	61
Peas and oats (green, in blossom),	1	3	70	70	57	76	68	49
Vetch and oats (green, in blossom),	1	3	67	75	47	68	68	53
Corn ensilage (Pride of the North),	1	2	74	45	77	82	80	26
Hominy meal,	1	1	89	53	94	94	-	-
Cerealine feed,	1	3	90	80	81	95	82	-
Peoria gluten feed,	1	3	91	85	88	95	-	-
Quaker oat feed,	1	3	62	81	89	67	43	-
Victor corn and oat feed,	1	3	75	71	87	83	48	-
H. O. dairy feed,	1	2	65	78	85	70	41	-
H. O. horse feed,	1	1	70	74	84	79	35	-

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

Soil Tests.

During the past season four soil tests upon the co-operative plan agreed upon in Washington in 1889 have been carried out. Two of these were upon our own grounds, — one with corn and the other with onions as the crop; one in Norwell, Plymouth County, with oats; and one in Montague, Franklin County, also with oats.

1. Soil Test with Corn. Amherst.

The past is the tenth season that the experiment on this field has been in progress. The crops in order of rotation have been corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch crop, rye, soy beans, white mustard, and this year corn once more. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer; three have received but a single important manurial element, — every year the same; three have received each year two important elements; one has received all three yearly; and one each has received yearly lime, plaster and farm-yard manure. It will be seen that the greater part of the field has remained either entirely unmanured or has had but a partial manuring, and it will be readily understood that the degree of exhaustion of most of the plots is considerable. The nothing plots produce this year an average of about twelve bushels of shelled corn per acre; and even this figure is somewhat too high, owing to the fact that after this long period one of the nothing plots which adjoins the plot which has been yearly manured at the rate of five cords per acre begins to feel the effect of the high fertility of its neighbor, although separated from it by a strip three and one-half feet wide.

The single-element plots, one receiving nitrate of soda only yearly, another phosphoric acid and the third potash, give this year practically equal crops of grain, respectively at the rate of 20.6, 18.5 and 19.8 bushels per acre. The nitrate of soda and dissolved bone-black give a crop at the rate of 32 bushels per acre, while nitrate of soda and potash give at the rate of but 10.9 bushels. The dissolved bone-black and muriate of potash do much better, yielding at the rate of 41.2 bushels. The fertilizer supplying nitrogen, phosphoric acid and potash gives a crop of 55.9 bushels, while manure gives 67.7 bushels.

It may be remembered that in each of the three previous years in which this field has produced corn the muriate of potash has, whether singly or in any combination, proved much more useful than either of the other fertilizers used. There is much evidence in the behavior of the crops this year, during the growing season and in the results, that this salt is proving injurious in its chemical effect upon the soil. I believe this effect to be a loss of lime in the form of chloride by leaching, but cannot regard this as yet proven. I will present the facts apparently bearing upon the case, and leave full discussion to a later report.

1. During the early part of the growing season the corn upon all the plots which had received muriate of potash was distinctly behind that upon other plots.

2. As the season advanced, the corn upon these plots gradually lost its sickly appearance, gained upon that in the other plots, eventually excelling, in the case of the plot receiving nitrogen, phosphoric acid and potash, that in all other plots except the manure plot.

3. This unhealthy appearance of the corn early in the season, followed by great improvement later, is analogous to effects noticed in other experiments,* where chlorides have been used, and where liming the land has remedied the faulty condition.

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* For example, Plot 6, Field A. See report State Experiment Station for 1896.

4. On that plot receiving dissolved bone-black as well as muriate of potash, the crop was in the end a good one. As is well known, the dissolved bone-black contains a large amount of sulphate of lime. It is believed that this may take the place of the lime leached from the soil as a consequence of the use of the muriate of potash, or at least that it corrects in some way the faulty condition consequent upon the use of this salt. It may here be pointed out that a similar corrective influence is evident in the results obtained both in 1897 and 1898 upon our other home-test acre, which will immediately be discussed.

It is of interest, further, to point out that the crop this year upon the lime plot was not quite equal to the average of the nothing plots, while that of the plaster plot (sulphate of lime) was about double that of the lime plot. In the earlier years of this soil test the yield of neither the lime nor the plaster plot ever exceeded that of the nothings, but for the past three years the plaster plot has been relatively gaining. The explanation of this difference between the effect of plaster and lime is not apparent. It will be made the subject of future study.

Conclusions.

1. The yield of the plot which for ten years has received only phosphoric acid and potash (41.2 bushels per acre) illustrates in a striking way the comparative independence of the corn crop of supplied nitrogen upon this soil.

2. The crop raised where nitrogen, phosphoric acid and potash have been yearly applied (nitrate of soda, dissolved bone-black and muriate of potash) for ten years shows that profitable results may be obtained by the use of fertilizers alone. The yearly cost of the application to this plot has been from $10 to $12. The crops have not been much inferior to those on the plot to which manure at the rate of 5 cords per acre has been yearly applied. The two crops this year are, respectively: for the fertilizer, 55.9 bushels; for the manure, 67.7 bushels. The extra 11 bushels of corn will not cover the added cost of the manure, as compared with the fertilizer; and in earlier years the differences in yield have been relatively much smaller than this year.

3. The problems suggested by the results of the year must be regarded as the most valuable product of this experiment. These problems are not solved. Their solution will throw important light upon methods to be employed in compounding and selecting fertilizers.

2. Soil Test with Onions. Amherst.

This experiment occupied a field which has been employed in work of this kind for nine years, the several plots having been every year manured alike, as described under the "Soil test with corn." The crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, and potatoes. The land was ploughed in the fall of 1897, and sown with winter rye as a cover crop. The rye was turned in before it had made much of a spring growth, April 21. Fertilizers were employed this year in double the usual quantities; viz., nitrate of soda at the rate of 320 pounds; dissolved bone-black, 640 pounds; and muriate of potash, 320 pounds, per acre. These fertilizers are each used upon one plot singly, in pairs, and upon one plot all three together.

The seed was sown in the customary manner, but more thickly, on May 9. Germination was prompt and perfect. The development of the crop throughout the season was most suggestive in problems for future solution. At the start plants upon the four plots, potash alone, potash and bone-black, potash and nitrate, and potash with both bone-black and nitrate, were much ahead of those on the plots not manured with potash. There was every indication that this element would almost entirely control the crop, for there was good growth wherever potash was applied, and but feeble growth elsewhere. The potash plots, however, after about four weeks, began to lose their superiority; and it was not long ere many of the plants upon these plots became manifestly very unthrifty, and before the end of the season many of them had died. Meanwhile, the phosphoric acid plots began to gain; and the results show that this, more than either the nitrogen or the potash supply, controlled the product. The crop was very light, however, even upon the best plot, which was at the rate of 116.9 bushels per acre, upon the plot receiving nitrate of soda and dissolved bone-black. Upon the plots receiving these two fertilizers and muriate of potash the crop amounted to only 16.3 bushels per acre. Here is strong evidence that the muriate of potash has produced in the soil of this field conditions absolutely prejudicial to the growth of the onion.

Last year this field was in potatoes under the same system of manuring, but with half the quantities employed this year. The crop of potatoes on the nitrate and bone-black was much heavier than on these two and potash, and in commenting upon this fact in my annual report I wrote: "The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which these two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must, therefore, conclude that some disturbing factor, at present unknown, influenced the results."

In view of the similar relative results upon the two plots under discussion this year, I am now forced to conclude that I was mistaken last year in supposing that the superiority of the plot receiving nitrogen and phosphoric acid only was not "the effect of the fertilizer alone."

I now believe that the muriate of potash has proved actually injurious to the last two crops, and that the explanation (the loss of lime which it causes) already suggested accounts for this effect.

The Proper Course as regards Potash Supply.

What, then, in view of such results, are we to recommend? Clearly not to cease using potash, — we have been unable to raise good crops without it. It is believed the remedy will be found in one of three directions; viz., (1) the occasional liberal use of lime where muriate of potash is employed; (2) the use of other potash salts, such as carbonate or sulphate; or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulphate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, supply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

Again, in conclusion it may be said the most profitable results of the year's work are the suggestions for future lines of work, which, being completed, must throw much needed light upon the problems connected with the use of fertilizers.

3. Soil Test with Oats. Norwell.

The past was the third season of soil test work upon this acre, the two preceding crops having both been corn. The results with both of the tests with corn have indicated a strong demand for potash by corn on this soil. These results were thus in entire agreement with those obtained in almost all of the large number of soil tests with this crop that during the past ten years have been carried out under my direction in all the counties of the State.

The results the past season with oats seem also to be in general accord with results previously obtained in other sections with this crop. This is not shown clearly by the figures giving the yields, for the reason that excessive rains flooded parts of the field which is nearly flat soon after the seed was sown, rendering germination poor and uneven.

From examination during the growing season I feel certain that in this experiment it was the nitrate of soda which most largely benefited the crop. The crop on dissolved boneblack was at the rate of 9.7 bushels per acre; on dissolved bone-black and nitrate of soda it was 13 bushels. On muriate of potash the crop was 10 bushels; on the muriate and nitrate of soda it was 13.6 bushels. On the bone-black and muriate of potash the crop was at the rate of 9.8 bushels per acre; on these two fertilizers and nitrate of soda it was 17.8 bushels. The soil is clearly in need also of both phosphoric acid and potash for good crops, although the figures of this year afford no certain index to its condition, owing to the damage by water above mentioned.

4. Soil Test with Oats. Montague.

The present is also the third season of soil test work upon this soil, the preceding crops having been corn, which, owing to accidental conditions, did not give decisive results. The experiment of the past season is eminently satisfactory. The five nothing plots have given fairly even crops, varying from 18.8 to 24.4 bushels per acre of grain, averaging 21.5 bushels; while the straw yield has varied on these plots from 1,470 to 1,830 pounds, averaging 1,554 pounds, per acre. The crop on nitrate of soda alone was 30.3 bushels of grain and 2,210 pounds of straw; on dissolved bone-black, 24.4 bushels and 1,550 pounds; on muriate of potash, 21.3 bushels and 1,470 pounds. This marked increase on the nitrate of soda, as compared with the almost complete absence of effect of the other fertilizers used alone, is striking.

The dissolved bone-black and muriate of potash together gave 23.8 bushels of grain and 1,810 pounds of straw. Again we see practically no effect; but when we use nitrate of soda with these two fertilizers, we have a crop of 31.3 bushels of grain and 2,710 pounds of straw. Nitrate of soda with muriate of potash gives 30.3 bushels and 2,350 pounds, and with dissolved bone-black it gives 31.3 bushels and 2,330 pounds.

It will be seen, then, that in this experiment it was the nitrate of soda alone which proved effective. Alone and in all its combinations it gave a large increase in crop, and in all cases practically the same. The average increase apparently due to the use of this fertilizer amounted to 8 bushels of grain and 804 pounds of straw. The average increases apparently due to the use of dissolved bone-black were 2.1 bushels of grain and 193.4 pounds of straw; those apparently due to the muriate of potash were 1 bushel of grain and 175 pounds of straw.

Manure at the rate of 5 cords per acre gave about 806 pounds more straw, but only .7 bushels more grain than the complete fertilizer, costing some $13 per acre less; and the manure crop did not indeed surpass the crop on nitrate of soda alone in much greater degree. The latter application cost $3.20 per acre, while the manure can scarcely be estimated at less than $25.

This Montague experiment is one of the most perfectly satisfactory in a long series of such experiments; and it is a pleasure to see that its teaching as to the value of nitrate of soda for the oat crop is so entirely in agreement with that of other experiments with this crop.

For convenience is appended a statement giving the arrangement of plots and the system of manuring in nearly all our soil test work, which now extends over ten seasons: —

Plot 1, nothing.
Plot 2, nitrate of soda, 160 pounds per acre.
Plot 3, dissolved bone-black, 320 pounds per acre.
Plot 4, nothing.
Plot 5, muriate of potash, 160 pounds per acre.
Plot 6, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre.
Plot 7, { nitrate of soda, 160 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 8, nothing.
Plot 9, { dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 10, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 11, plaster, 160 pounds per acre.
Plot 12, nothing.
Plot 13, manure, 5 cords per acre.
Plot 14, lime, 160 pounds per acre.
Plot 15, nothing.

Manure Alone v. Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a smaller application of manure used in connection with muriate of potash was begun in 1890. A full account will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn of 1896. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash was used in 1897. The field includes four plots, of one-fourth an acre each. The average results for 1897 are shown below: —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92; 4 cords, 1893–96; and potash, 160 pounds per acre): hay, 961¼ pounds; rowen, 536½ pounds.

This field was continued in grass and clover during the present season, but manure and potash were applied as shown below: —

Plot 1, manure, 1 cord; weight, 5,087.5 pounds.

Plot 2, { manure, .5 cord; weight, 2,712.5 pounds.
muriate of potash; weight, 40 pounds.

Plot 3, manure, 1 cord; weight, 5,372.5 pounds.

Plot 4, { manure, .5 cord; weight, 2,855 pounds.
muriate of potash; weight, 40 pounds.

The manure applied to each plot was sampled and analyzed, and from the analyses the amounts of the three most essential elements of plant food applied per acre were calculated, with results shown below: —

Manurial Ingredients per Plot.

Plots.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plot 1, in manure,	20.9	14.2	25.9
Plot 2, in manure,	11.4	6.2	15.2 } 35.1
Plot 2, in muriate of potash,	–	–	19.9
Plot 3, in manure,	22.0	15.0	26.9
Plot 4, in manure,	15.1	9.7	18.0 } 37.9
Plot 4, in muriate of potash,	–	–	19.9

The manure was applied on April 1, the muriate of potash to plots 2 and 4 on April 9.

During the later growth of the mixed grasses and clovers upon these plots it was plainly evident that the clover was relatively more prominent upon plots 2 and 4. The first crop was cut on June 20; the second, on August 26, and both were secured in excellent condition.

Yield per Plot.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1,	1,395	840
Plot 2,	1,120	730
Plot 3,	1,460	810
Plot 4,	1,497	830

Average Yield per Acre.

Plots 1 and 3 (manure alone),	5,710	3,300
Plots 2 and 4 (manure and potash),	5,235	3,120

Combining the figures showing the yields in hay and rowen, we find that the average of plots 1 and 3 is at the rate of 9,010 pounds per acre; and of plots 2 and 4, 8,355 pounds. There is, then, a difference of 655 pounds only in total yields per acre, in favor of the large application of manure alone. This amount is quite insufficient to cover the larger cost of the acre application ($6.80 in the case of the manure alone). This field has now been broken up, and will next year be put once more into corn, when it is believed the beneficial effect of the large growth of clover upon plots 2 and 4 will become apparent.

"Special" Corn Fertilizer *v.* Fertilizer Richer in Potash.

This experiment was begun with a view to comparing the results obtained with a fertilizer proportioned like the average "*special" corn fertilizers* found upon the markets in 1891 with those obtained with a fertilizer richer in potash, but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots of one-fourth of an acre each. The materials supplied to the several plots are shown in the following table: —

Fertilizers.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	20.0	18.0
Dried blood,	30.0	30.0
Dry ground fish,	30.0	20.0
Plain superphosphate,	226.0	120.0
Muriate of potash.	22.5	60.0
Cost of materials per plot,	$3 23	$3 10

In 1897 the average (both hay and rowen) produced by plots 1 and 3 was 873.5 pounds, or 3,494 pounds per acre; on plots 2 and 4, 860.5 pounds, or 3,442 pounds per acre. This difference is too small to be of practical significance. The rowen crop was heavier on plots 2 and 4 than on plots

1 and 3, showing an apparent influence of the greater amount of potash used on these plots in a larger proportion of clover.

For the present season the fertilizers were applied as last year, being evenly broadcasted on April 11. The first crop was cut June 21. It consisted largely of red-top, which was then not fully in bloom. The second crop was cut August 26. Both crops were well secured, and the yields are shown below: —

Yield of Hay and Rowen, 1898.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1 (lesser potash),	670	530
Plot 2 (richer in potash),	585	440
Plot 3 (lesser potash),	540	365
Plot 4 (richer in potash),	550	415

Average Rates per Acre.

Plots 1 and 3,	2,420	1,790
Plots 2 and 4,	2,270	1,710

We have then, as will be seen, an average product, from the application richer in nitrogen and phosphoric acid, at the rate of 150 pounds of hay and 80 pounds of rowen per acre more than from the application poorer in these elements and richer in potash. It is believed that the failure of plots 2 and 4 to show greatly superior development of clover is in part due to variations in physical characteristics of the soil of the different plots, leading to unfavorable moisture conditions, which prevented an even catch of clover on plots 2, 3 and 4, but did not injuriously affect Plot 1. Further, it should be pointed out that results which will be published later in this report in the case of clover experiments on a series of plots manured alternately with muriate of potash and with sulphate of potash indicate that the long-continued use of muriate of potash in liberal amounts without liming is unfavorable to the healthy development of clover. This field has now been broken up, and will be again put into corn next season.

Leguminous Crops (Clover, Pea and Bean or "Pod" Family) as Nitrogen Gatherers. (Field A.)

This experiment is a continuation of a series begun in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure as sources of nitrogen.*

The plots, eleven in number, are one-tenth acre each, and are numbered 0 to 10. Three plots (4, 7 and 9) have received no nitrogen-containing manure or fertilizers since 1884; one (0) has received farm-yard manure; two (1 and 2), nitrate of soda; three (5, 6, and 8), sulphate of ammonia; and two (3 and 10), dried blood every year since 1889. These materials have been used in amounts to furnish nitrogen at the rate of 45 pounds per acre each year.

All the plots have received yearly equal quantities of phosphoric acid and potash; viz., 80 pounds per acre of the former and 125 pounds of the latter from 1889 to 1894 and the past two seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulphate; to others, in the form of muriate. The results with the former salt have been superior to those with the latter, as a rule, particularly when used in connection with sulphate of ammonia.

Up to this year we may briefly characterize the results, in so far as these have a bearing upon the two main questions proposed, as follows: —

1. The leguminous crops grown (soy beans in 1892, 1894 and 1896) have not appeared to enrich the soil in nitrogen, if we accept the results with the next following crop as affording a basis of judgment.

2. The different sources of nitrogen have ranked on the

* Only such details are given here as are necessary to an understanding of the nature of the experiment. Full particulars will be found in our ninth and tenth annual reports.

average in the following order: nitrate of soda, farm-yard manure, dried blood and sulphate of ammonia.

After the oat crop of 1897 was harvested the land was ploughed, and late in July sown to Mammoth red clover. Germination was quick and good; but the young plants on all plots failed to flourish, and soon took on a most unhealthy appearance on all except the manure plot, and even on this their development was not what could be desired. In April of this year the plots were most carefully examined, and the clover ranked as follows: plot 0, good; 1, fair; 2, poorer than 1; 3, like 2; 4, mostly dead; 5, all dead; 6, all dead; 7, like 2; 8, best in field (limed in 1896); 9, like 2; 10, somewhat better than 2.*

The general average of condition was so poor that it was decided to plough the field, which was done on April 18. From previous observations upon this series of plots it was decided that liming was called for, and accordingly 200 pounds per plot of partially air-slaked lime was spread on and harrowed in on April 20. Eight hundred pounds of manure was applied to plot 0 on April 23, and on April 26 the fertilizers were applied.

The plots were all sown to Clydesdale oats on April 27, 8½ pounds per plot. The analysis of the manure and a table showing fertilizer treatment and yields follow: —

Analysis of Manure Used.

	Per Cent.
Moisture,	72.53
Nitrogen,	.43
Phosphoric acid,	.16
Potash,	.26

* For manuring of these plots, see page 58.

Nitrogen Experiment. — Fertilizer Treatment and Yields of Oats, 1898.

PLOTS	FERTILIZERS.	Pounds.	Weight of Oats (Pounds).	Weight of Straw (Pounds).	Bushels Oats per Acre.	Weight of Straw per Acre (Pounds).
Plot 0,	Barn-yarn manure, . . . Potash-magnesia sulphate, . Dissolved bone-black, . .	800.0 32.0 18.0	83.0	125	25.90	1,250.0
Plot 1,	Nitrate of soda, . . . Potash-magnesia sulphate, . Dissolved bone-black, . .	29.0 48.5 50.0	103.0	150	32.20	1,500.0
Plot 2,	Nitrate of soda, . . . Potash-magnesia sulphate, . Dissolved bone-black, . .	29.0 48.5 50.0	115.0	175	35.90	1,750.0
Plot 3,	Dried blood, . . . Muriate of potash, . . Dissolved bone-black, . .	43.0 25.0 50.0	96.0	155	30.00	1,550.0
Plot 4,	Muriate of potash, . . Dissolved bone-black, .	25.0 50.0	56.0	80	17.50	800.0
Plot 5,	Ammonium sulphate, . . Potash-magnesia sulphate, . Dissolved bone-black, . .	22.5 48.5 50.0	103.0	135	32.20	1,350.0
Plot 6,	Ammonium sulphate, . . Muriate of potash, . . Dissolved bone-black, . .	22.5 25.0 50.0	109.0	160	34.10	1,600.0
Plot 7,	Muriate of potash, . . Dissolved bone-black, .	25.0 50.0	72.5	95	22.70	950.0
Plot 8,	Ammonium sulphate, . Muriate of potash, . . Dissolved bone-black, .	22.5 25.0 50.0	123.0	155	38.40	1,550.0
Plot 9,	Muriate of potash, . . Dissolved bone-black, . .	25.0 50.0	76.5	95	23.90	950.0
Plot10,	Dried blood, . . . Potash-magnesia sulphate, . Dissolved bone-black, . .	43.0 48.5 40.0	112.0	135	35.00	1,350.0
Average of no-nitrogen plots, ...					21.40	900.0
Average of muriate of potash plot (as far as comparable), . . .					32.05	1,595.0
Average of sulphate plots (as far as comparable), ...					35.20	1,416.7

It is important to point out that the oats on the several plots ripened at different times. An effort was made to harvest the crop upon all at the same stage of maturity. With this end in view, plots 1, 2 and 5 were cut on July 29; plots 6, 8, 9 and 10, on July 30; and the balance on August 2. Meanwhile, there had occurred the phenomenally heavy rain and wind of July 30, P.M., and numerous other heavy showers; moreover, the weather continued persistently bad much of the time until the middle of August, and there was much loss through shelling of the grain. The straw, therefore, perhaps better than the grain, affords an index to the relative value of the several manurings. The rank of the different sources of nitrogen, taking straw production as the basis of estimation, is nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure.

After the oats were harvested the land was ploughed, and without further manuring sown to Mammoth red clover, which at the time winter set in was in excellent condition.

The reader will naturally, perhaps, conclude that the better condition of the clover this year as compared with last is a consequence of the liming, and I am of opinion that this may be the case; but nevertheless I cannot regard this as certain, for the reason that upon Field B (reported upon below), where clover sown in the summer of 1897 failed, we have now an excellent stand of this crop obtained by sowing seed where it had failed this spring, without liming or reploughing.

Muriate *v.* Sulphate of Potash for Clover. (Field B.)

Field B is laid off in eleven equal plots, of two-fifteenths of an acre each. The manuring has been uniform since 1884. These plots are numbered from 11 to 21. *Every year each plot has received an application of ground bone at the rate of 600 pounds per acre. The odd-number plots have yearly received muriate of potash and the even-number plots the high-grade sulphate, in each case at the uniform rate of 400 pounds per acre.* This series of plots has produced a great variety of crops, including potatoes, corn, grasses, oats and barley each, with vetches, rye and clovers. The crops have been generally excellent. Full details will be found in the tenth and twelfth annual reports of the State Experiment Station, and the reports of the Hatch Experiment Station for the last three years. In the summer of 1895 two plots (one muriate the other sulphate) of each of the following clovers were sown: sweet clover (*Melilotus alba*), mammoth red clover, medium red clover and alsike clover. Between the crops produced respectively on the muriate and sulphate of potash no marked difference in yield was observed in either 1896 or 1897. It was, however, noticed in 1896 that the clover raised on the sulphate of potash was richer in starch and similar extractive substances, in the case of the mammoth, medium and alsike clovers, than that raised on the muriate, thus making the sulphate clover the more valuable.

Bad Effect of the Muriate.

In August of 1897 the plots were ploughed and all again seeded to the same varieties of clover. Germination was excellent, but within a very few weeks after the young plants appeared it was observed that in the case of the mammoth, medium and alsike varieties the plants were doing very poorly upon the muriate plots. As the autumn advanced, these plants for the most part grew more and more feeble, and many died. The winter was favorable to newly seeded land; but in the spring it was found that a large proportion of the plants upon the muriate plots were dead, in the case of the varieties above named. The sweet clover showed no difference between the two fertilizers. The condition of the clovers upon the sulphate plots was not entirely satisfactory, although far superior to that upon the muriate.

It was decided to sow additional seed upon all the plots without reploughing. Accordingly, on April 2, 4 pounds of seed of the appropriate variety were sown upon each of the plots. The conditions were favorable to germination, and a good stand of young clover was obtained upon all the plots. The sulphate plots gave much the larger yields of clover this season, because they contained a far larger proportion of the older plants from last summer's sowing. At the present time, however, the condition of the clover upon the muriate and sulphate plots is fairly even, for the spring-sown clover has done equally well upon both the potash salts.

This record of facts is made without comment, as without further investigation it appears to be impossible to explain why the summer-sown clover failed on the muriate, while the spring-sown has flourished upon the same plots without reploughing or any change in treatment.

Muriate v. Sulphate of Potash for Corn. (Field B.)

Two plots in Field B, one muriate and one sulphate, were planted to Sibley's Pride of the North corn, with a view to testing the relative value of these two potash salts for this crop. It will be remembered that these plots have been under the same manurial treatment since 1884. The fertilizers were broadcasted after ploughing, and harrowed in, and the corn was planted on May 30, in drills 3½ feet apart. It was later thinned to 1 foot in the drills. The crop was cut September 9 and husked the middle of October.

Corn on Muriate and on Sulphate of Potash.

Manuring per Acre.	Corn (Pounds).	Stover (Pounds).	Yield per Acre.	
			Corn (Bushels).	Stover (Pounds).
Plot 19, { Muriate of potash, 400 pounds, Ground bone, 600 pounds, }	488.5	866	45.8	6,495
Plot 20, { Sulphate of potash, 400 pounds, Ground bone, 600 pounds, }	428.5	652	40.1	4,890

The apparent superiority of the crop raised on the muriate of potash is considerable. During the growth of the crop, as the result of frequent examinations, no such difference was evident; and it is regretted that the moisture test has not been completed in season for this report, as it is felt that there may have been a difference in condition of the two crops when weighed, owing to the very rainy weather of the autumn.

Sweet Clover (*Melilotus alba*).

As has been stated under "Muriate v. Sulphate of Potash for Clovers," sweet clover occupied two of the plots in Field B. The present is the third successive year that this clover has been grown upon these plots, and the soil appears now to have become thoroughly stocked with the nodular bacteria peculiar to the plant. As reported in 1896, but few of the plants on these plots in that year possessed bacteria, and only those which did made vigorous growth. The next year, as already reported, about one-half of the plants apparently possessed nodules and made vigorous growth early in the season. Later all seemed to acquire the ability to make use of the atmospheric nitrogen which these nodular bacteria give. The crop of this season has been extremely vigorous from the very first. The rapid growth of this legume in early spring seemed to indicate its possible value as a cover crop for green manuring; and to test this point one square yard (believed to be average) was harvested at each of three different dates, and a determination of dry matter and of nitrogen contained therein was made. The results calculated per acre were: —

Date.	Height (Feet).	Dry Matter (Pounds).	Nitrogen (Pounds).
June 6, ...	2½	3,661.6	136.8
June 15, ...	3½	3,961.7	130.2
July 10, ...	5½	7,573.0	192.5

The crop was in full bloom at the time the last cutting was made, but it goes on blooming freely for almost the entire summer.

Corn for the silo may here be planted up to the middle of June, with a good prospect of success; and, as will be seen, previous to that date the sweet clover makes a large growth and contains a heavy amount of nitrogen. The amount of this element at the date of the second cutting is equivalent to that contained in about 6 cords of rich manure. To what extent, however, this nitrogen has been taken from the soil, and to what extent from the air, our experiments afford us no means for determining. Kühn has pointed out that the acquisition of atmospheric nitrogen by plants of the clover family takes place most abundantly in the later stages of their growth; and that, if they be ploughed under immature, we can hope for but little gain in that element. Our experiment, then, is not conclusive, as yet, as to the value of this clover as a green manuring crop. Since, however, being sown in the latter part of July or early in August, it will afford winter protection to the soil and furnish a large growth before late corn planting time, it seems worthy of further trial.

Value for Bees.

As is known to many, this clover furnishes an abundant and long-continued supply of honey. For many weeks the plants in our plots were daily visited by countless myriad bees, and the rate of honey production of those kept near by was very rapid, The honey is of good quality.

High-priced Seed an Obstacle to the Use of Sweet Clover.

The high price at which the seed of this clover is at present offered in our markets constitutes a great obstacle to its use as a green manuring crop. Recognizing this fact, and wishing to determine whether the seed might not be more cheaply offered, our crop of this year was allowed to mature. The sulphate of potash plot (two-fifteenths acre) gave a product of 43.5 pounds and the muriate plot 46.5 pounds of rather poorly cleaned seed. It is true that the season was unfavorable to the ripening of the seed; but the indication of this single experiment is that the species can not be counted upon for a liberal seed product, and that, therefore, the seed must remain high in price.

Nitragin, A Germ Fertilizer.

In connection with my report upon sweet clover, it has been shown that in the early attempts to cultivate this crop but partial success was obtained, because the germs of the appropriate nodular bacteria (microscopic plants, which, growing in nodules upon the roots, give the power of assimilating the free nitrogen of the air) were not present in sufficient numbers. It is there pointed out that, after three years' culture of the sweet clover upon the same plots, these bacteria so multiplied in the soil that complete success with the clover followed. Similar results in the first attempts to cultivate plants of the "pod" family (*Leguminosæ*) in localities where they had not been before grown have many times been observed; and many times, also, has ultimate success crowned the effort to produce the new plant, and for the reason above alluded to. The attainment of success in this manner, however, requires some few years; and time is precious. Recognizing this fact, an attempt to propagate the bacteria connected with nitrogen assimilation artificially and to put them upon the market was some few years ago made by Professor Nobbe of Tharandt, Germany. The effort was successful, and the product, under the name *Nitragin*, has been offered for the past few years by a German firm with which Professor Nobbe completed arrangements for its production and sale. Full particulars concerning *Nitragin*, and directions for its use, will be found in our eleventh annual report. The unsuccessful results of its trial upon clover in 1897 are published in our last annual report.

The scientific standing of Professor Nobbe is such and the general importance of the subject so great that further trials and with other plants seemed desirable. Accordingly, nitragin for the following species was ordered direct from the makers: crimson clover, red clover, alfalfa, sweet clover, soy bean, vetch and pea.

The experiments are not yet complete, but are being carried out upon poor plain land hired for the purpose, where most of these crops have never been cultivated, as well as upon our own grounds. The plan of the experiment upon the plain land is shown below.

Plan of Nitragin Experiments.

The plots are one-twentieth of an acre each, duly separated by dividing strips. The treatment of the several plots for each crop will be clear from the table: —

Plot 1, no fertilizers. No nitragin.
Plot 2, no fertilizers. Nitragin.
Plot 3, { acid phosphate, 400 pounds per acre. muriate of potash, 250 pounds per acre. lime, 1,000 pounds per acre, } No nitragin.
Plot 4, manurial treatment, like Plot 3. Nitragin.
Plot 5, same manures as 3, and, in addition, 180 pounds per acre of nitrate of soda. No nitragin.

The plan upon the home grounds is similar, with two exceptions: (1) The plots are smaller, and (2) there are no plots left unfertilized.

The crops started in the spring upon the "plain" include field peas, alfalfa, alsike clover and common red clover. The peas were harvested early in August. The yields of the several plots were very small, and showed no favorable influence from the nitragin. Of all the other crops, it can be reported to-day that the general condition is poor; that the best condition is to be found in every case upon Plot 5 (supplied with available fertilizer nitrogen), and that the crop upon mineral fertilizers with nitragin (4) appears somewhat better than the corresponding plot (3) without nitragin. Between plots 1 and 2 there appears to be no appreciable difference.

Upon our home grounds the field pea with nitragin gave a slightly better crop on mineral fertilizers alone than on mineral fertilizers without nitragin. Alfalfa upon mineral fertilizers and nitragin now looks better than on the same fertilizers without nitragin. It will be seen, then, that thus far the experiments of this season afford indications that some slight benefit has followed the use of this germ fertilizer.* Of the crops sown in late summer it is as yet too early to report.

Fertilizers for Garden Crops.

This series of experiments, begun in 1891, was originally intended to test the value for the different garden crops of nitrate of soda, sulphate of ammonia and dried blood as sources of nitrogen; but in the second year it was made to include also a comparison of muriate with sulphate of potash, each used with each of the three nitrogen fertilizers, for the same class of crops. Dissolved bone-black has been applied equally to all the plots from the first. The number of plots and the fertilizers annually applied to each up to the present year are shown in the following table: —

* It may be useful, though this fact has already many times been pointed out, to remark here that a third, and often very satisfactory, method of securing a stock of nodular bacteria consists in taking earth from soil where the crop under trial flourishes, and incorporating a little, as one might fertilizer, with the soil where the new crop is to be grown. This method is now under trial here with alfalfa with soil from Kansas.

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply, at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The management of the experiment and results and conclusions are presented in great detail in our eighth, ninth and tenth annual reports, and to these the student of these experiments is referred. It suffices for our present purpose to call attention to the general results up to the end of the year 1897, which are shown below: —

Averages of Garden Crops, 1892 to 1897, inclusive.

PLOTS.	Spinach, grown Three Years (Pounds).	Lettuce, grown Three Years (Pounds).	Tomatoes, grown Four Years (Pounds).	Beans, grown Three Years (Pounds).	Onions, grown Two Years (Pounds).	Sweet Corn, grown Two Years (Pounds).	Green Peas, grown One Year (Pounds).	Table Beets, grown Two Years (Pounds).
Plot 1,	153	37	482	43	111	144	177	255
Plot 2,	210	43	707	49	326	179	203	479
Plot 3,	182	42	577	50	259	160	281	372
Plot 4,	196	63	717	44	221	151	348	425
Plot 5,	232	66	790	59	298	143	343	591
Plot 6,	149	41	503	51	235	154	307	483

It is important to point out that none of the crops included above has in any year occupied the whole of the area under experiment. Each year we have had some four or five crops, and the areas in each have varied. The above figures are valuable, then, solely as a basis of comparison between the several plots.

Conclusions based on Results up to 1897.

The chief conclusions which seemed justified by the results above given are the following: —

1. Sulphate of potash in connection with nitrate of soda (Plot 5) has generally given the best crop. In those cases where this has not been true, the inferiority of this combination has usually been small. In one case only has it fallen much behind, viz., with sweet corn, a crop which makes much of its growth in the latter part of the season.

2. Nitrate of soda (plots 2 and 5) has in almost every instance proved the most valuable source of nitrogen, whether used with muriate or the sulphate of potash.

3. The combination of sulphate of ammonia and muriate of potash (Plot 1) has in every instance given the poorest crop. This fact is apparently due, as Dr. Goessmann has pointed out, to an interchange of acids and bases leading to the formation of chloride of ammonia, which injuriously affects growth.

The Experiment in 1898.

In the fall of 1897 the plots were ploughed, and rye sown on all (without further manuring) as a cover crop, chiefly to prevent soil washing. The growth on Plot 1 (sulphate of ammonia and muriate of potash) was sickly and feeble, but no particular difference was noticed between the other plots.

Change in Plan.

In view of the fact that market gardeners, in whose interests chiefly these experiments are being carried out, almost invariably use large quantities of stable manure, and employ fertilizers, if at all, simply to supplement the manure, it was decided to make a change in the plan of the experiment, in order that the conditions under which we are working may more nearly conform to those of the average market gardener.

Accordingly, it was decided to apply equal amounts of thoroughly mixed stable manure to each plot, and to use on each, in addition, the same fertilizers as heretofore. Further, in order to have a basis for determining whether the fertilizers should prove in any degree useful, another plot was added, to which manure alone is applied. It was impossible to secure for this purpose a plot of exactly the same shape as the others, and of course it has not had the same history. It is, however, contiguous, and it has the same elevation and similar soil. This plot, which will be called plot 0, has for the past fifteen years received an annual application at the rate of ground bone 400 pounds and muriate of potash 200 pounds per acre. It has been planted yearly with a variety of the newer forage crops. Manure was applied at the rate per acre of twelve cords to all of the seven plots. The manure was applied by measure, but it was also weighed. The table shows the weight applied to each plot and the quantities of plant food which it carried: —

Plots.	Manure (Pounds).	Nitrogen (per Cent.).	Potassium Oxide (per Cent.).	Phosphoric Acid (per Cent.).
Plot 0,	6,720	28.8960	10.7520	17.4720
Plot 1,	6,977	30.0011	11.1632	18.1402
Plot 2,	6,775	29.1325	10.8400	17.6150
Plot 3,	7,065	30.3795	11.3040	18.3690
Plot 4,	6,617	28.4531	10.5872	17.2042
Plot 5,	7,210	31.0030	11.5360	18.7460
Plot 6,	6,945	29.8635	11.1120	18.0570
Manure contained,	–	.0043	.0016	.0026

Details.

The manure was evenly spread upon the surface April 18–23. The land was ploughed April 27, a thin crop of rye, previously alluded to, being turned under. The fertilizers were applied evenly, broadcast as in previous years, on May 2, and harrowed in. The land was once more harrowed on May 5. Throughout the season all plots received clean culture.

The crops the past season have been: strawberries (Clyde), spinach, lettuce, table beets, tomatoes, cabbage, celery and potatoes; and, as a second crop, turnips.

Clyde Strawberries. — Three rows were set in each plot. The growth was vigorous and healthy on all plots. Plots 4, 5 and 2 now show a slight superiority over the others, while Plot 0 is the poorest. All are well stocked, in matted rows.

Long Standing Spinach. — Three rows of this crop were planted in each plot May 7. All germinated well, but by June 9 many plants were dying on plots 1 and 4 (sulphate of ammonia and muriate of potash, and sulphate of ammonia and sulphate of potash), while nearly all the plants in these plots appeared yellow and sickly. All the spinach was harvested in two cuttings. The yields in pounds were as follows: Plot 0, 69; Plot 1, $1\frac{1}{4}$; Plot 2, $156\frac{1}{2}$; Plot 3, $77\frac{3}{4}$; Plot 4, $13\frac{1}{2}$; Plot 5, $159\frac{1}{2}$; Plot 6, $73\frac{3}{4}$.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (Plot 0), ...	88.7
Average of manure and muriate of potash (plots 1, 2 and 3), .	78.5
Average of manure and sulphate of potash (plots 4, 5 and 6), .	82.3
Average of manure and sulphate of ammonia (plots 1 and 4), .	7.4
Average of manure and nitrate of soda (plots 2 and 5), . .	158.0
Average of manure and dried blood (plots 3 and 6), . .	75.8

It will be noticed that the muriate of potash plots are inferior to those receiving sulphate of potash, though the difference is small. The sulphate of ammonia plots proved almost an absolute failure, while the dried blood gave a much smaller crop than the nitrate of soda. The most important fact brought out is the marked superiority of the latter as a source of nitrogen for spinach.

Hanson Lettuce. — Two rows of this crop, planted May 7, were grown in each plot, the plants being brought by

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* To enable the reader the better to make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulphate of potash," etc. It should be remembered that dissolved bone-black was applied to all except Plot 0, and that every plot received material supplying both nitrogen and potash as well as phosphoric acid in addition to the manure. For the full list of fertilizers applied to each plot, see page 66.

thinning and resetting to a uniform distance of 1 foot in the rows, except on plots 1 and 4, where a large number of the plants died soon after coming up. In harvesting, the heads of market size were cut from day to day. The total crop in pounds on the several plots was: Plot 0, 179¼; Plot 1, 40; Plot 2, 194¼; Plot 3, 220¾; Plot 4, 135; Plot 5, 219; and Plot 6, 231¼.

The average yields, in pounds, produced by the different fertilizers were: —

Manure alone (Plot 0, *corrected for area*), . . .	230.5
Manure and muriate of potash (plots 1, 2 and 3), . .	151.7
Manure and sulphate of potash (plots 4, 5 and 6), . .	195.1
Manure and sulphate of ammonia (plots 1 and 4), . .	87.5
Manure and nitrate of soda (plots 2 and 5), . . .	206.6
Manure and dried blood (plots 3 and 6), . . .	226.0

The manure alone gave, as will be seen, a larger yield than any of the plots to which fertilizers as well as manure were applied. The only point clearly indicated is the apparent highly injurious effect of the sulphate of ammonia, particularly where used with the muriate of potash.

Dewing's Blood Turnip Beet. — Six rows of this crop, planted May 7, were grown in each plot. In plots 1 and 4 most of the plants soon became weak and sickly and many died, and there were not enough to restock to the uniform distance of 4 inches in the row, to which all the other plots were brought by thinning and resetting where needed. The few plants in plots 1 and 4 which survived until about July 1 then appeared to recover their vigor, and grew very rapidly. The yields of roots and tops were as shown below: —

Plots.	Beets (Pounds).	Tops (Pounds).
Plot 0, ...	340	440
Plot 1, ...	80	160
Plot 2, ...	440	570
Plot 3, ...	365	515
Plot 4, ...	260	470
Plot 5, ...	460	490
Plot 6, ...	325	335

The average yields in pounds per plot were as follows: —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	374.7	484.9
Manure and muriate of potash (plots 1, 2 and 3),	295.0	415.0
Manure and sulphate of potash (plots 4, 5 and 6),	348.3	431.7
Manure and sulphate of ammonia (plots 1 and 4),	170.0	315.0
Manure and nitrate of soda (plots 2 and 5),	450.0	530.0
Manure and dried blood (plots 3 and 6),	345.0	425.0

The general result here is similar to that with spinach; *i.e.*, muriate is inferior to the sulphate of potash; nitrate of soda is the best source of nitrogen; and sulphate of ammonia shows itself to have been actually injurious, particularly so with muriate of potash.

Dwarf Champion Tomato. — Two rows were set in each of the original six plots and three in Plot 0, the plants, purchased of the Horticultural Department, being rather small and uneven. The crop was picked as it ripened until September 23, when the balance of the fruit was picked green. The weights of ripe and of green fruit in pounds per plot are shown below:* —

Plots.	Ripe Fruit.	Green Fruit.
	Lbs. oz.	Lbs. oz.
Plot 0,	422 3	179 8
Plot 1,	387 7	223 0
Plot 2,	501 4	160 0
Plot 3,	328 2	178 0
Plot 4,	430 6	181 0
Plot 5,	413 1	84 8
Plot 6,	405 4	181 8

The averages of ripe fruit and total yield in pounds per plot were as shown in the table: —

* The record of one day's picking of ripe fruit was lost, but this does not change the relative standing of the plots.

	Ripe Fruit.	Total.
Manure alone (Plot 0, corrected for area),	361.9	515.7
Manure and muriate of potash (plots 1, 2 and 3),	405.6	592.6
Manure and sulphate of potash (plots 4, 5 and 6),	416.2	565.2
Manure and sulphate of ammonia (plots 1 and 4),	408.9	610.9
Manure and nitrate of soda (plots 2 and 5),	457.2	579.4
Manure and dried blood (plots 3 and 6),	366.7	546.4

The differences brought out by these averages are much smaller than in the case of the spinach and beets, but are in the same direction for ripe fruit; *i.e.*, sulphate of potash gives somewhat better returns than muriate, and nitrate of soda gives the largest yield of any of the sources of nitrogen. It is noteworthy that the sulphate of ammonia does not appear to have injuriously affected this crop. This is perhaps due to the fact that the tomato is not set until about the first of June, and makes most of its growth when the season is well advanced. The crops shown to have been injured by the sulphate of ammonia, spinach and beets, are sown early, and make most of their growth before the season is far advanced.

Fotler's Drumhead Cabbage. — Two rows in each of the original six plots and three in Plot 0 were grown. The seed was planted May 23, in hills, and later thinned to one in each hill, those destroyed by maggots being replaced. Owing to the unusually hot season, the crop was well grown by September 1, and numerous heads were beginning to crack. They were harvested as they matured, September 8 to November 5. The yield in pounds of heads, practically all well filled and hard, was as follows: Plot 0, 729; Plot 1, 720; Plot 2, 780; Plot 3, 710; Plot 4, 755; Plot 5, 744; and Plot 6, 651.

The average yields in pounds per plot were as follows: —

Manure alone (Plot 0, corrected),	624.9
Manure and muriate of potash (plots 1, 2 and 3),	736.7
Manure and sulphate of potash (plots 4, 5 and 6),	716.7
Manure and sulphate of ammonia (plots 1 and 4),	737.5
Manure and nitrate of soda (plots 2 and 5),	762.0
Manure and dried blood (plots 3 and 6),	680.5

Here we find the fertilizers have apparently produced a moderate increase in crop. The differences between them are far less marked than in the case of most of the other crops grown this year. The nitrate of soda appears to have been the best source of nitrogen for the cabbage.

Early Maine Potatoes. — The seed planted was grown in the State of Maine. It was treated with corrosive sublimate solution, for prevention of scab, and sun-sprouted. Before planting, the tubers were cut to pieces with two eyes each. Three rows per plot (4 on Plot 0) were grown. The seed was planted on May 9 in rows 3 feet apart, the pieces being dropped 1 foot apart in the rows. Ordinary thorough culture was given until the vines covered the ground. The vines were sprayed with Bordeaux mixture (first on June 7) to repel the flea beetle. They were sprayed with sufficient frequency to keep the vines well covered with the mixture until the middle of August, the last application being made August 8. The Bordeaux mixture was applied nine times in all, frequent re-application being necessary, on account of the numerous heavy rains. The vines were slightly attacked by blight about the middle of July; but later in August new shoots were thrown out from the axils of the lower leaves, making a healthy growth, which remained green until very late in September. The tubers averaged large and smooth, and showed very little rot when dug. A few weeks after storing there were a few more decayed tubers. The yield in pounds was as follows: —

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0,	441.5	41.0
Plot 1,	449.0	40.0
Plot 2,	426.0	40.0
Plot 3,	409.0	62.5
Plot 4,	550.0	35.0
Plot 5,	482.0	31.5
Plot 6,	482.0	51.5

Yield per Acre (Bushels).

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0,	381.5	35.4
Plot 1,	447.2	35.8
Plot 2,	381.7	35.8
Plot 3,	366.5	56.0
Plot 4,	492.8	31.4
Plot 5,	431.9	28.3
Plot 6,	431.9	46.1

The averages calculated to show the relative effect of the different fertilizers are given below in pounds per plot: —

Plots.	Merchantable Tubers.	Small Tubers.
Manure alone (Plot 0, corrected),	425.7	39.5
Manure and muriate of potash (plots 1, 2 and 3),	444.7	47.5
Manure and sulphate of potash (plots 4, 5 and 6),	504.7	39.3
Manure and sulphate of ammonia (plots 1 and 4),	524.5	37.5
Manure and nitrate of soda (plots 2 and 5),	454.0	35.8
Manure and dried blood (plots 3 and 6),	445.5	57.0

It becomes evident from a study of these figures that the fertilizers proved moderately beneficial to this crop, and that the sulphate of potash is superior to the muriate. The various sources of nitrogen rank in the order, sulphate of ammonia, nitrate of soda and dried blood, the first giving a much larger average crop than either of the others. It seems further important to point out that the combination sulphate of ammonia with muriate of potash, which has proved both in previous years and in this year so fatal to most crops, has given a fine crop of potatoes, at the rate of 447 bushels to the acre, the second in rank among the seven plots. No explanation can be offered, beyond that already suggested in the case of tomatoes, viz., that the potato has a much longer growing season than the crops doing so very poorly on this combination of fertilizers. It seems reasonable to suppose that, as the season advances, the injurious ammonium chloride formed at first is either washed out of the soil or destroyed by further chemical changes. This question will be made a matter of further study.

The spraying with Bordeaux mixture, although necessarily nine times repeated on account of the unusual number of heavy rains, must be considered to have been profitable, as the yield was very heavy, while in general the crop this year was light where spraying was not practised.

Giant Pascal Celery. — Two rows were grown in each plot; the plants, large and well grown, were set 1 foot apart in rows 5 feet apart on July 19. Banking began September 29, and the crop was put into the cellar in good condition on November 4. The growth on plots 0, 1 and 4 was fair; on the other plots, excellent. There was considerable rust on Plot 0, while there was little or none on the other plots. The weights in pounds of the plants (including roots and a little earth) were as follows: Plot 0, 443; Plot 1, 328; Plot 2, 478; Plot 3, 478; Plot 4, 348; Plot 5, 568; Plot 6, 488.

The calculated averages will not be given until the crop is blanched, since the earth, of necessity left adhering to the roots of the plants as put into the cellar, is an element of uncertainty. It may be of interest to state that these averages indicate little if any increase which can be attributed to the fertilizers.

White Egg Turnips. — This crop followed spinach, lettuce and table beets, without further manuring. The land was reploughed and fitted and the seed sown on July 28, in rows 14 inches apart. Soon after sowing a heavy shower caused some washing across the plots, which was particularly injurious on Plot 0. The crop was harvested November 8 and 9, and was of excellent quality. The yields in pounds are shown in the following table: —

Plots.	Roots.	Tops.
Plot 0,	580.0	185
Plot 1,	702.0	348
Plot 2,	753.5	315
Plot 3,	735.0	315
Plot 4,	938.0	335
Plot 5,	655.0	260
Plot 6,	690.0	215

The calculated averages in pounds are given in the following table: —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	688.3	219.7
Manure and muriate of potash (plots 1, 2 and 3),	730.3	326.0
Manure and sulphate of potash (plots 4, 5 and 6),	761.0	270.0
Manure and sulphate of ammonia (plots 1 and 4),	820.0	341.5
Manure and nitrate of soda (plots 2 and 5),	704.3	287.5
Manure and dried blood (plots 3 and 6),	712.5	265.0

The fertilizers are shown to have been moderately beneficial, there is not much difference between the two potash salts, and the sulphate of ammonia gives a much better crop than either of the nitrogen fertilizers. This is not strange, in view of these facts: (1) the plots to which this had been applied had produced but very small first crops, while the others had yielded heavily; and (2) that the turnips made their growth so late in the season that the injurious compounds often formed by this salt had become dissipated, or destroyed by further chemical changes.

Experiments in Manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued. We have three large plots (between two and three acres each) under this treatment. Under this system each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds and muriate of potash 200 pounds per acre; and the third year, manure at the rate of 8 tons. The system is so planned that each year we have one plot under each manuring. The manure is always applied in the fall, the other materials early in the spring; this year April 8 and 9.

Plot 1, which this year received bone and potash, gave a yield at the rate of 5,137 pounds of hay and 2,370 pounds of rowen per acre. Plot 2, which received ashes, yielded 4,602 pounds of hay and 2,142 pounds of rowen. Plot 3, which was dressed with manure in the fall of 1897, yielded 5,233 pounds of hay and 2,823 pounds of rowen per acre. This field has now been ten years in grass, and during the continuance of the present system of manuring (since 1893) has produced an average product (hay and rowen both included) at the rate of 6,808 pounds per acre. The plots when dressed with manure have averaged 7,211 pounds per acre; when receiving bone and potash, 6,671 pounds per acre; and when receiving wood ashes, 6,541 pounds per acre.

Variety Tests.

Our work in testing varieties this year has been confined to testing the potato. With this it has been extensive. The tests have been of two sorts; (1) a preliminary test with varieties grown for the first time; and (2) a test of the best twenty-five varieties, as indicated by the trial of last year.

1. *Preliminary Test.* — As has been stated in my previous reports upon variety work with the potato, I consider several years' trial necessary to the formation of a judgment. The seed of new varieties as they are brought out must of necessity come from many widely separated localities. Such seed is unfit to serve as a basis for comparison, with the object of determining the relative merits of varieties, as it is well known to many and quite generally admitted that the place where any given variety of seed potatoes is produced may greatly influence its product. Newly obtained varieties must also of necessity have been subjected to widely variant conditions of handling, preservation and

transportation, and all these factors influence product. For all these reasons our practice is to obtain but a small quantity of seed of new varieties as they come to our attention, and to plant this for the purpose of raising seed for the next year's trial, which shall have been produced under similar conditions and similarly handled. This constitutes our "*preliminary test.*"

This test the past season included seventy-five varieties, obtained from almost as many seedsmen, scattered all over New England, the middle and central States and Canada. The seed of all was treated with corrosive sublimate solution and sun-sprouted. It was then cut to pieces of two good eyes each, and planted one piece to a foot, in rows 3 feet apart. The soil was a good medium loam, naturally well drained. The fertilizers used in pounds per acre were: —

Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed just before using, and scattered broadly in the drills before dropping the seed. The planting took place May 11 and 12. All varieties were injured by hot, dry weather, which came just as the tubers were forming, and by blight, although sprayed with Bordeaux mixture six times between June 13 and August 2. The varieties on which blight was first noticed were Salzer's Earliest, Bliss Triumph, King of the Earliest and Lincoln, — July 24 and 25. All other varieties showed blight between July 28 and August 1, and to about an equal degree. It is thought that no varieties blighted long before they were mature; but, nevertheless, the blight undoubtedly greatly reduced the yields. Owing to the blight, the period of apparent ripening of all varieties was nearly the same, viz., August 27 to September 8. The potatoes were dug late in September. The average number of sets for each variety was about forty, and to this number the yield of all has been corrected. Such correction, in our experience, always proves unduly favorable to the varieties of which we have the least seed. Our effort has always been to obtain just three pounds of each variety; but sometimes we are unable to obtain so much, or it may be that some tubers obtained prove unfit to plant, owing to bruising or decay.

The yield this year has varied from 8.5 to 46.7 pounds of merchantable tubers for 40 sets.* Six varieties have given a yield of 40 pounds or above of merchantable tubers from 40 sets, viz., Ford's No. 31, 46.7; Early Minnesota, 44.7; Champion of the World, 41.8; Burr's No. 1, 40.8; and American Wonder and Early Dawn, 40 each. Eight varieties gave under 20 pounds from 40 sets, viz., Lady Finger, 8.5; Mayflower, 13.9; Salzer's Earliest, 14.2; Potentate, 15.3; Mills's Long Keeper, 16; Livingston's Pinkeye, 16.8; and King of the Earliest and White Beauty, 18.5 each.

2. *Test with Twenty-five Varieties (the Best of Last Season).* — The seed of these varieties, it will be understood, was all of our own growing, and was of most excellent quality. It was prepared for planting as above described, and was planted upon similar soil and similarly manured. One hundred sets of each variety were planted on May 13. These varieties were sprayed six times, as were those in the preliminary test. They, however, showed considerable blight, and doubtless gave diminished yields because of this affection. The yields have been calculated to 40 sets, to make them comparable with the varieties in the other test. These are shown in the table following: —

* Forty pounds for 40 sets corresponds to a yield of 242.4 bushels per acre.
Thirty pounds for 40 sets corresponds to a yield of 181.8 bushels per acre.
Twenty pounds for 40 sets corresponds to a yield of 121.2 bushels per acre.

Variety Test of Potatoes. Yield in Pounds from 40 Sets.

Variety.	Merchantable Tubers.	Small Tubers.
Beauty of Hebron,	33.40	7.00
Bliss's Triumph,	20.40	9.60
Carmen No. 1,	23.40	12.80
Dakota Red,	19.20	10.80
Dutton's Seedling,	32.20	15.20
Early Maine,	21.20	2.80
Early Rose,	28.00	9.00
Early Sunrise,	26.40	10.80
Empire State,	12.40	7.60
Enormous,	36.80	4.20
Fillbasket,	37.60	5.60
Late Puritan,	26.80	9.60
Money Maker,	26.60	7.40
New Satisfaction,	26.60	6.00
Prolific Rose,	28.20	8.00
Restaurant,	34.80	7.60
Rochester Rose,	29.60	8.80
Rose No. 9,	34.00	5.20
Sir William,	26.80	6.20
State of Maine,	34.00	4.80
Thorburn,	35.80	6.40
Uncle Sam,	28.40	3.80
Vanguard,	31.80	9.00
White Elephant,	40.20	8.00
Woodbury's White,	35.90	5.00

Last year the eleven best varieties ranked in yield of merchantable tubers in the following order: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these then gave a product at the rate of more than 220 bushels of merchantable tubers per acre.

This year the relative rank, as will be seen, is quite different. The yields are in general much lower. The results of this year, however, owing to the blight, cannot be regarded as affording a reliable index to the relative merits of the varieties. Their publication, however, serves to illustrate how almost impossible it is, in the making of such tests, to establish the relative merits of varieties. As I have remarked in previous reports, it is significant that the old standard, Beauty of Hebron, is once more one of the first ten varieties.

Identical Varieties under Different Names.

As far as we are able to judge, there is no difference between King of the Earliest and Early Ohio; Salzer's Earliest and Bliss's Triumph; Mills's Banner and Livingston's Banner; while White Beauty and Cambridge Russet differ but very slightly, the latter having a slightly more russetted skin than the former.

Test of Seed of the Same Variety from Different Localities.

In order to test the soundness of the *a priori* conclusion that, to make the results of a variety test comparable for the purpose of determining relative merits, the seed of all should have been produced in the same locality and handled in all respects alike, an experiment was carried out with two of the old standard sorts, — Beauty of Hebron and Early Rose, — with seed of each from a considerable number of sources. The seed of the former came from eight different producers; that of the latter, from six. The methods pursued in seed preparation, soil, manuring, spraying, etc., were in all respects as in the variety test.

Comparison of Seed Potatoes from Different Localities. Yield in Pounds of 40 Sets.

Source of the Seed.	Varieties.			
	Beauty of Hebron.		Early Rose.	
	Merchantable.	Small.	Merchantable.	Small.
Home grown,	30.0	2.5	25.0	2.9
Guelph, Ontario, D. of C.,	32.3	1.8	–	–
Pennsylvania grown, Dreer,	24.5	3.3	27.5	3.5
James J. H. Gregory, Marblehead, Mass.,	35.5	2.5	–	–
Cornell Experiment Station, Ithaca, N.Y.,	29.3	2.5	31.0	2.0
Wisconsin, Olds Seed Company,	26.0	4.5	–	–
Maine, A. H. Weeks Company,	33.3	2.8	–	–
Dibble Seed Company, N. Y.,	26.5	3.8	32.5	2.0
Minnesota, Farmer Seed Company,	–	–	21.0	3.8
Kansas, F. Barteldes & Co.,	–	–	20.0	7.8

The range of variation in yield, as will be seen, is large, amounting to almost 50 per cent. in the yield of merchantable tubers for the Beauty of Hebron and to rather over 50 per cent. for the Early Rose. In view of this wide difference in the yield of the same variety, it must be admitted that variety tests in which the seed is brought together from many sources can have but a doubtful value.

The extent of the variation in the type of the potatoes grown in this test was considerable, so great, indeed, as to make it doubtful whether in all cases the seed was true to name, although obtained from the most reliable parties in every instance. The extent of the variation is in part shown in the table below, in which each lot is compared with the crop from our home-grown seed of the same variety: —

Potatoes. — Comparison of Crops, Seed from Different Sources.

Origin of the Seed.	Shape.	Color.	Size.	Eyes.
Beauty of Hebron.				
Home grown, . .	Long, elliptical, slightly flattened, tapering strongly towards tip.	Light flesh, mottled with darker shades.	Medium,	Medium, rather deep.
J. J. H. Gregory, . .	Same, . . .	Same, . . .	Same, .	Smaller, less deep.
Dreer, Pennsylvania, .	Shorter, . . .	Same, . . .	Larger, .	Same.
Olds Company, Wisconsin.	Oval, slightly flat, same at both ends.	Lighter, . . .	Smaller,	Small.
Weeks Company, Maine.	Same, . . .	Same, . . .	Larger, .	Less deep.
Cornell Experiment Station.	Same, . . .	Light, bright pink,	Larger, .	Smaller.
Guelph, Ontario, Experiment Station.	Same, . . .	Same, . . .	Same, .	Same.
Dibble Company, N. Y.,	Same, . . .	Lighter, . . .	Same, .	Same.
Early Rose.				
Home grown, . .	Long, flattened, tapering towards seed end, curved.	Light pink, bright pink at seed end.	Medium,	Medium large.
Dreer, Pennsylvania, .	Broader, more compact.	Lighter, . . .	Same, .	Same.
Farmer Company, Minnesota.	Much broader, less curved.	Same, . . .	Smaller,	Same.
Cornell Experiment Station.	Longer, more curved.	Same, . . .	Larger, .	Same.
Kansas, Barteldes & Co.,	Broader, more like Hebron.	Same, . . .	Same, .	Smaller, more shallow.
Dibble Company, N. Y.,	Same, . . .	Same, . . .	Larger, .	Large, shallow.

Individual Variation, Tubers of the Same Variety.

In view of the frequently reported tests of varieties in which some two or three tubers only of each are used, it was thought best to carry out an experiment to determine if possible the extent to which the product of single tubers will vary when grown under conditions as favorable as possible to uniformity of yield. As a preparation for this test, tiles two feet in diameter and four feet long were set into the ground in a single row, the distance between them being about two and one-half feet. To insure equal drainage conditions, a drain tile was laid at about the level of the lower edge of the tile, being given just enough pitch to carry off water. The plot of land in which the tiles were set was surrounded with drain tile, to prevent the ingress of soil water from outside. This plot had been uniformly manured for many years, so that the subsoil conditions below the tiles must have been practically uniform. The plots were set so that the surface water from outside was excluded, but the earth outside was brought to within about one inch of the upper edge.

These tiles so set were filled to within one foot of the top with carefully mixed subsoil, consisting of a very fine sand, this subsoil being settled by the liberal use of water. After this subsoil had thoroughly settled and somewhat dried, equal weights of carefully mixed medium loam were put into each tile, the quantities being sufficient to fill them. The amount used was two hundred and twenty-five pounds for each tile. Conclusive evidence that the work was well and uniformly done is afforded by the fact that the earth in the several tiles remained at practically uniform height throughout the season.

With the upper four inches in depth of soil in these tiles were most carefully mixed the fertilizers applied, precisely the same weights as determined by chemical balances to each tile. The materials used supplied per tile and at the rate per acre as follows: —

Materials Used.	Per Tile (Grams).	Rate per Acre (Pounds).
Nitrate of soda,	8.07	250
Dried blood,	3.23	100
Tankage,	8.07	250
Acid phosphate,	12.92	400
Sulphate of potash (high grade),	9.69	300

This fertilizer was applied May 9, and the seed was planted the same day. The variety was Carmen No. 1. The tubers selected were uniform in form, weight and all external characteristics, as far as it was possible to obtain such. The weights of the tubers were as follows: No. 1, 160 grams; No. 2, 135 grams; No. 3, 160 grams; No. 4, 140 grams; No. 5, 135 grams; No. 6, 140 grams; No. 7, 140 grams; No. 8, 140 grams. The first seven tubers were treated with corrosive sublimate solution, and sun-sprouted; No. 8 was not treated. Each tuber was cut to exact halves by weight, and the number of eyes on each half reduced to five in the same part of the tuber. The tubers were all typical of the variety, and all were entirely free from scab, but there had been a few scabbed potatoes in the crop from which they came. They were all planted face downward at the same depth, the halves of tuber No. 1 in tiles 1 and 2, the halves of tuber No. 2 in tiles 3 and 4, and so on, — and finally one-half of tuber No. 8 in tile 15. They all came up in good season, but somewhat irregularly, May 26 to May 28. They were most carefully cultivated by hand, kept entirely free from weeds and from bugs by hand pulling and picking. Bordeaux mixture was applied six times, June 6 to July 25. There was practically no injury from either flea beetle or blight. The vines in different tiles showed quite different minor characteristics, and ripened unevenly, September 20 to October 1, when the crop was harvested. At that time there was a very little yellowish-green color on part of one stalk in tile 9 and on one entire stalk in tile 8. All leaves had for some time been dead. The yields and remarks are given in the table: —

Yield of Different Tubers, Carmen Potato.

No. of Tuber.	Tile.	Number of Tubers.	Weight (Kilograms).*	Remarks.
Tuber No. 1, . . .	1 2	10 14	1.470 1.520	
Tuber No. 2, . . .	3 4	14 11	1.300 1.340	One scabby.
Tuber No. 3, . . .	5 6	15 10	1.440 1.440	Several slightly scabby.
Tuber No. 4, . . .	7 8	12 8	1.180 1.330	Small amount of scab.
Tuber No. 5, . . .	9 10	17 15	1.440 1.620	A very little scab.
Tuber No. 6, . . .	11 12	19 9	1.460 1.340	A little scab.
Tuber No. 7, . . .	13 14	13 14	1.240 1.450	A little scab.
One-half of Tuber No. 8, .	15	16	1.320	Considerable scab.

* The kilogram equals almost exactly 2.2 English pounds.

The above weights were taken after the tubers had been carefully washed and dried. They showed a range of variation amounting between halves to a little over 37 per cent., and between tubers of about 22 per cent. The differences in number and size of tubers are equally striking. In view of these facts, I submit that variety tests of potatoes upon a small scale can have but a small value for determining the probable relative yield of varieties.

Poultry Experiments.

The experiments with poultry completed since our last annual report were begun in the late fall of 1897, and extended through the winter of 1897 and 1898, and a part of them through the past summer and into the fall. The points upon which these experiments were designed to afford information are the following: —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of flesh or animal meal and cut fresh bone.

3. Comparison for egg-production of a wide nutritive ration with a narrow; or, in other words, of a ration in

which corn meal and corn were prominent with one in which these feeds were replaced wholly or in large part with more nitrogenous foods, such as wheat middlings, gluten feed, wheat and oats.

4. The influence of the presence of a cock with the hens upon egg-production.

General Conditions.

In all these experiments pullets purchased in Plymouth County and reaching us about the middle of October were used. These pullets were well-bred Barred Plymouth Rocks, not fancy stock (*i. e.*, as to feather), but bright, healthy stock, hatched in April. These pullets were evenly divided into lots of twenty each, being matched in sets of two lots as closely as possible. Each lot occupied a detached house, including laying and roosting room ten by twelve feet and scratching shed eight by twelve feet, with the run of large yards of equal size whenever weather permitted. The winter tests began December 12 and ended April 30. The latter part of March a few hens were removed from each house for sitters, the same number from each. Egg records of the separate lots were kept from the time laying began to the time of beginning experiments, for the purpose of affording an index as to the equality or otherwise of the matched pairs of lots. The hens were all marked with leg bands, as a precautionary measure for the purpose of identification in the case of accidental mixture of fowls.

All the meals and the cut clover were given in the form of a mash, fed early in the morning. This was mixed the night before with boiling water until January 8, and fed at the temperature of about 70° F. After January 8, the mashes were mixed with boiling water in the morning, and fed hot. At noon a few oats were scattered in the straw with which the scratching sheds were littered. At night the balance of the whole grain was fed (also by scattering in the straw) one hour before dark. The fowls were given what whole grain they would eat up clean. Water, shells and artificial grit were kept before the fowls at all times. About twice a week a small cabbage was given to each lot of fowls, this, like all other food, being weighed. The eggs from each lot were weighed weekly. The fowls were all weighed once each month.

No male birds were kept in any of the pens in the winter experiments, nor, indeed, in any except where the influence of the cock was the subject of experiment. Sitters, except those taken out, above alluded to, were confined in a coop until broken up, being meanwhile fed like their mates.

The prices per hundred weight for foods, upon which financial calculations are based, are shown below: —

Wheat,	$1 75
Oats,	1 00
Wheat bran,	60
Wheat middlings,	75
Gluten feed,	2 00
Animal meal,	2 00
Cut clover rowen,	1 50
Cabbage,	25
Cut bone,	2 00
Gluten meal,	80
Corn meal,	85
Corn,	85

Composition of Foods (Per Cent.).

KIND.	Moisture.	AIR DRY FOOD CONTAINS —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Whole wheat,	10.51	1.85	12.64	2.55	71.01	1.44
Whole oats,	8.06	3.21	11.96	11.64	61.48	3.65
Cut clover rowen,	9.80	7.36	17.88	22.18	39.70	3.08
Wheat middlings,	9.25	4.63	17.52	9.91	53.11	5.58
Animal meal,	5.06	39.26	37.66	1.01	5.56	11.45
Whole corn,	12.11	1.31	9.55	1.90	71.26	3.87

KIND.	Moisture.	DRY MATTER CONTAINS —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Bran,	12.72	6.96	18.01	11.65	57.92	5.46
Gluten feed,	9.10	0.92	24.59	7.17	63.43	3.89
Corn meal,	13.43	1.46	11.01	1.96	81.44	4.13
Cabbage,	89.45	7.94	25.69	9.31	54.76	2.30
Cut bone,	26.29	21.50	20.62	–	–	31.38
Gluten meal,	8.77	1.50	37.64	3.87	54.59	2.40

1. Effect of Condition Powder upon Egg-production.

Each coop contained twenty pullets at the beginning of the experiment; the fowls in the no condition-powder coop weighing 103 pounds, and having laid, November 18 to December 12, 46 eggs; the fowls in the condition-powder coop weighing 97 pounds, and having laid 14 eggs. The rations of the two lots of fowls were the same, except to the morning mash of one lot was added condition powder to the full amount recommended by makers; viz., 3 scoops (provided for measuring) heaping full. This amount of condition powder was enough to make the mash several shades darker than the one without it, and to impart a strong odor. Being mixed sometimes in the room where milk was standing, it imparted a flavor to butter made therefrom which was recognized by our expert butter maker, who knew nothing concerning its use, and who worked in rooms a quarter of a mile distant, to which the milk was taken. The pen receiving the powder consumed during the winter four two-pound cans of it, costing at retail $4.

Both lots of fowls were healthy throughout the entire test. Two fowls were stolen from the lot receiving no condition powders on the night of March 27. One soft-shelled egg was laid by a fowl receiving condition powder. The tables give all details necessary to a comparison of the results: —

Foods consumed, Condition-powder Experiment.

Kinds of Food.	Amount.			
	Condition Powder.		No Condition Powder.	
	Lbs.	oz.	Lbs.	oz.
Wheat,	269	0	250	0
Oats,	155	0	152	0
Bran,	44	0	44	8
Middlings	44	0	44	8
Gluten feed,	44	0	44	8
Animal meal,	52	0	52	8
Clover,	43	0	44	8
Cabbage,	15	15	15	3

Average Weights of the Fowls (Pounds).

Dates.	Condition Powder.	No Condition Powder.
December 12,	4.85	5.15
January 31,	5.21	5.41
February 25,	5.44	5.53
March 30,	5.25	5.48
April 30,	5.11	4.88

Eggs per Month (Number).

Months.	Condition Powder.	No Condition Powder.
December,	28	59
January,	90	66
February,	86	101
March,	217	288
April,	298	291
Totals,	719	745

Condition Powder for Egg-production (December 12 to April 30).

	Condition Powder.	No Condition Powder.
Hen days,	2,751	2,656
Gross cost of food,	$8 91	$8 59
Cost per hen day,	$0 0032	$0 0032
Total number of eggs,	719	745
Cost per egg, not including powder,	$0 0124	$0 0115
Cost per egg, including powder,	$0 0180	$0 0115
Eggs per hen day,	.26+	.28+
Total weight of eggs (pounds),	88.08	90.80
Average weight of eggs (ounces),	1.96	1.95
Dry matter to produce 1 egg (pounds),	.82	.77
Dry matter consumed per hen day (pounds),	.22–	.22–
Nutritive ratio,	1:4.6+	1:4.6–
Sitters,	8	14

Eggs from both lots of fowls were tested under numbers by two families. One family reports no difference; the other found the eggs from the hens not getting the powder "much preferable" to the others.

Conclusion.

A study of the figures showing results shows that the hens not getting the condition powder laid more eggs, of practically the same average weight. The food required to produce a single egg was less, and the cost was very materially less. The average weight of the fowls not getting the powder at the close of the experiment was about one-quarter of a pound less than that of the other.

We have now carried through three experiments to test the value of condition powder for egg-production. The differences have in every case been small. In favor of the condition powder we have one experiment, against it we have two experiments. It is not, however, my disposition to claim that the powder is injurious, but simply *that it is not beneficial.* This the four experiments, carried out with the utmost fairness and with every care, certainly prove. *In the light of these results, it is believed that poultry keepers throw away money expended for condition powder.*

2. Animal Meal v. Cut Bone for Egg-production (December 12 to April 30).

In this experiment there were nineteen pullets in each house when the experiment began. Those in the animal-meal house weighed 101.5 pounds, and had laid, November 8 to December 12, 82 eggs. The pullets in the cut-bone coop weighed 101.25 pounds, and had laid 41 eggs.

In the morning mash of one lot one part animal meal to five parts total dry materials was used; in the mash of the other lot, the same proportion of fresh-cut bone was mixed. The large, flat bones, comparatively free from meat or fat, were used.

In the animal-meal coop the health of the birds was good, but one fowl being out of condition in any way. She became sick about April 1, and was killed, as she seemed to be growing gradually worse, on April 10. The nature of the trouble was unknown. Almost from the first, bowel troubles were not uncommon in the cut-bone coop. Two fowls died (December 23 and January 11) after short illness. On April 11 one hen was found with a disjointed leg, and she was killed. The animal-meal coop laid three soft-shelled eggs; the other, two.

The bone fed amounted to only .27 ounce per hen daily. One-half ounce and over is the usual recommendation by writers upon the subject. We find it impossible to feed so largely without serious bowel trouble.

Foods consumed, Animal Meal v. Cut Bone.

Kinds of Food.	Animal Meal.		Cut Bone.	
	lbs.	oz.	lbs.	oz.
Wheat,	256	0	262	0
Oats,	143	0	145	0
Bran,	44	8	39	0
Wheat middlings,	44	8	39	0
Gluten feed,	44	8	-	
Gluten meal,	-		39	0
Animal meal,	44	8	-	
Cut bone,	-		40	0
Clover rowen,	44	8	39	0
Cabbage,	19	3	18	8

Average Weights of the Fowls (Pounds).

Dates.	Animal Meal.	Cut Bone.
December 12,	5.34	5.38
January 31,	5.64	5.66
February 25,	5.66	5.88
March 30,	5.09	5.27
April 30,	5.06	5.53

Eggs per Month (Number).

MONTHS.	Animal Meal.	Cut Bone.
December,	63	57
January,	92	83
February,	184	120
March,	263	259
April,	210	209
Totals,	812	728

Animal Meal v. Cut Bone for Egg-production.

	Animal Meal.	Cut Bone.
Total number of eggs,	812	728
Hen days,	2,561	2,331
Gross cost of foods,	$8 45	$8 29
Cost per egg,	$0 0104	$0 0114
Cost per hen day,	$0 0033	$0 0035
Total weight of eggs (pounds),	100.5	88.7
Average weight per egg (ounces),	1.98	1.95
Eggs per hen day,	.32	.31
Dry matter consumed per hen day (pounds),	.22	.23
Dry matter to produce 1 egg (pounds),	.695	.739
Nutritive ratio,	1:4.6	1:4.7
Sitters,	22	13

A test of the eggs both raw and boiled was made by an expert, who found the animal-meal eggs inferior, in color and flavor, to the others.

Conclusion.

In conclusion, then, I may quote the closing summary of results made in my report upon a similar experiment last year. "The advantage in this trial lies, then, clearly with the animal meal as a food for egg-production. It has given more eggs of greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer." In one respect only is the animal meal apparently inferior to the bone this year, viz., the fowls getting it weigh less at the close of the experiment than the others. This loss in weight is, however, far more than covered by the greater value of eggs produced.

We have now carried through five experiments, comparing these two feeds. Two have given results slightly favorable to the bone in number of eggs; one a similar result in favor of the animal meal; and two — the two last, which have been the most perfectly carried out — have been most decisively favorable to the animal meal. The latter has also been found the safer food. *The greatly preponderating weight of the evidence afforded by these experiments, which have been most carefully conducted, is, therefore, in favor of the animal meal.*

3. Narrow v. Wide Ration for Egg-production.

The experiments coming under this head have been two, one extending from December 12 to April 30, the other from May 1 to October 4. The object in view was to test the correctness of the generally held opinion that the food of the laying hen must be very rich in nitrogenous constituents. As we have carried out the experiment, it amounts to a substitution of corn meal for wheat middlings and gluten feed in the morning mash, and the replacement of about one-half of the oats and the wheat fed at night with the corn. The proportions of cut clover and of animal meal have remained the same in the two rations.

The health of the fowls on both rations has been uniformly good throughout both the winter and summer test, with a single exception, — the loss of one fowl from the effects of indigestion, — on the wide ration. It was found to require the exercise of more judgment in feeding to keep the fowls on the heavier corn ration in perfect condition. They were more easily overfed, and on two or three occasions lost appetite for their feed for short periods.

The Winter Experiment.

On December 12 the pullets, 19 in each lot, weighed as follows: narrow ration, 101.75 pounds; wide ration, 102.5

pounds. The first lot had laid, November 12 to December 12, 127 eggs; the other lot, 85 eggs, and one in this lot was broody. The foods consumed during the winter experiment and other details are shown in the following table: —

Foods consumed, Narrow v. Wide Ration (December 12 to April 30).

Kinds of Food.	Narrow Ration.	Wide Ration.
	lbs. oz.	lbs. oz.
Wheat,	257 0	126 0
Oats,	147 0	63 0
Bran,	43 0	39 0
Middlings,	43 0	–
Gluten feed,	43 0	–
Animal meal,	43 0	39 0
Clover,	44 0	39 0
Corn meal,	–	108 0
Corn,	–	136 0
Cabbage,	18 5	16 5

Average Weight of the Fowls (Pounds).

Dates.	Narrow Ration.	Wide Ration.
December 12,	5.36	5.39
January 31,	5.41	5.84
February 25,	5.45	5.80
March 30,	5.16	5.57
April 30,	5.17	5.31

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

Months.	Narrow Ration.	Wide Ration.
December 12 to 31,	94	89
January,	99	148
February,	147	258
March,	310	317
April,	210	259
Totals,	860	1,071

Narrow v. Wide Ration for Egg-production, Winter Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,529	2,538
Gross cost of foods,	$8 54	$6 56
Cost per hen day,	$0 0033	$0 0026
Total number of eggs,	860	1,071
Cost per egg,	$0 0099	$0 0061
Eggs per hen day,	.34—	.42+
Total weight of eggs (pounds),	102.425	130.53—
Average weight of eggs (ounces),	1.98	1.95
Dry matter to produce one egg (pounds),	.655	.46
Dry matter consumed per hen day (pounds),	.22	.19
Nutritive ratio,	1:4.7—	1:5.6—
Number of sitters,	30	24

Summer Experiment.

The summer experiment was continued with the same fowls that had been used in the winter. The method of feeding remained the same, save in two particulars: (1) in place of cut clover rowen in the mash every morning, lawn clippings in such quantity as the fowls would eat before wilting were fed three times per week, to each lot the same; and (2) the feeding of cabbages was discontinued. The yards (fifty by twenty-four feet) were kept fresh by frequent use of the cultivator. The health of one fowl only suffered during the experiment. One of the corn-fed fowls appeared dumpy for a few days, but was fully recovered in two weeks. As in the winter test, the fowls fed largely on corn showed less relish for their whole grain than the others. Food consumed and other details are shown below: —

Foods consumed, Narrow v. Wide Ration (May 1 to October 4).

Kinds of Food.	Narrow Ration.	Wide Ration.
	Lbs.	Lbs.
Wheat,	276	131½
Oats,	97	43
Bran,	43	40
Middlings,	43	–
Animal meal,	43	40
Corn meal,	–	106½
Corn,	–	217½
Gluten feed,	43	16

Average Weight of the Fowls (Pounds).

Dates.	Narrow Ration.	Wide Ration.
April 30,	5.17	5.31
June 11,	5.00	5.25
July 16,	5.47	5.22
August 11,	5.05	5.50
Before killing,	5.07	5.44
Dressed,	4.37*	4.81†

* Or 86 per cent. † Or 88 per cent.

Eggs per Month (Number).

Months.	Narrow Ration.	Wide Ration.
May,	216	292
June,	182	204
July,	157	210
August,	151	197
September,	139	174
October 1-14,	14	18
Totals,	859	1,095

Narrow v. Wide Ration for Egg-production, Summer Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,355	2,512
Gross cost,	$7 56	$6 64
Cost per hen day,	$0 0032	$0 0026
Total number of eggs,	859	1,095
Cost per egg,	$0 0088	$0 0061
Eggs per hen day,	.36	.44
Total weight of eggs (pounds),	106.3	130
Average weight of eggs (ounces),	1.98	1.90
Dry matter to produce one egg (pounds),	.57+	.48+
Dry matter consumed per hen day (pounds),	.21−	.21+
Sitters,	67	60

The fowls on the wide (corn) ration laid three soft-shelled eggs during the winter test and one during the summer. These are not included in the tabular reports.

Study of the results reveals the following facts: —

1. *The hens on the wide (rich in corn) ration laid a great many more eggs in both the winter and in the summer experiments than those on the narrower ration.*

2. *The difference in favor of the wide ration amounts to 25 per cent. in the winter trial and to 33⅓ per cent. in the summer trial, upon the basis of equal number of hen days.*

3. *The total cost of feeds was less for the wide ration, and of course the cost per egg was much less. In the production of one hundred dozen eggs the saving on the basis of our winter test would amount to $4.56; on the basis of the summer test, to $3.24.*

4. *In average weight of the eggs produced there is a small difference in favor of the narrow ration; but in quality the weight of family evidence shows the eggs produced by the corn-fed hens to have been somewhat superior. They were deeper yellow and of a milder flavor than the eggs from the narrower ration.*

5. *The fowls on the wide ration gained somewhat in weight and were heavier at the close of the experiment than the others, notwithstanding the much larger number of eggs laid.*

At the close of the experiment the fowls were closely judged as to the condition of the plumage while still living, and it was decided that the corn-fed hens were farther advanced in moulting than the others. The fowls were slaughtered, and the judgment of the men removing the feathers coincided with the judgment on the living fowls.

The averages before and after dressing were as follows: narrow-ration fowls, 5.07 pounds; dressed weight, 4.37 pounds; wide-ration fowls, 5.44 pounds; dressed weight, 4.81 pounds. The narrow-ration fowls gave 86 per cent. dressed weight; the others, 88 per cent. The dressed fowls were judged by a market expert, who pronounced the corn-fed fowls slightly superior to the others.

The results are thus greatly in favor of the ration richer in *corn meal and corn; and so important will a knowledge of this fact prove (if confirmed by further trials), because of the cheapness of these foods as compared with wheat, that the experiment is being repeated this year with three different breeds of fowls, using corn yet more largely than last year.*

4. *Influence of the Cock on Egg-production.*

At the close of the winter tests the hens that had been used in the condition-powder and cut-bone experiments were matched in such a manner as to equalize previous feed conditions in four coops of sixteen fowls each. The fowls were all put upon the same feed, and egg records were kept for two weeks, to determine whether the fowls seemed evenly matched. At the end of the time a vigorous White Leghorn cock was placed in two of the coops. We had thus two experiments co-incidently running. These will be designated respectively test No. 1 and test No. 2.

Test No. 1. Influence of the Cock on Egg-production. — In the preliminary trial the hens in pen 1 laid 129 eggs; those in pen 2, 107 eggs. In the first pen five hens were brooding; in the second, seven. The fowls in both pens were fed alike, each receiving, in addition to the feed recorded, lawn clippings three times per week. The experiment began May 13 and extended to September 2. In calculating the food cost per hen day the cock is included in the hen days, but in calculating the number of eggs per hen day the cock is not included. No ill health or accidents of any kind occurred. The cock in the trial was in pen 1.

Foods consumed (May 14 to September 2).

Kinds of Food.	Pen 1.	Pen 2.
	Lbs.	Lbs.
Wheat,	194	194
Oats,	82	78
Bran,	32	32
Middlings,	32	32
Gluten feed,	32	32
Animal meal,	32	32

Average Weight of Fowls (Pounds).

Dates.	Pen 1.	Pen 2.
May 14, beginning,	5.12	5.09
June 11,	4.69	4.91
July 16,	4.91	4.94
August 11,	4.87	5.09
September 1, end,	4.82	4.95

Influence of Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days, including cock,	1,904	-
Hen days, without cock,	1,792	1,792
Gross cost of food,	$5 53	$5 49
Cost per hen day,	$0 0029	$0 0031
Total number of eggs,	631	630
Cost per egg,	$0 0088	$0 0087
Eggs per hen day,	.35+	.36—
Total weight of eggs (pounds),	77.3	76.79
Average weight of eggs (ounces),	1.96	1.95
Dry matter consumed per hen day (pounds),	.19	.20
Dry matter consumed per egg (pounds),	.58—	.57+
Nutritive ratio,	1:4.7—	1:4.7
Sitters,	41	45

Test No. 2. Influence of the Cock on Egg-production. — During the preliminary period the fowls in pen 5 laid 90 eggs, three offering to sit; those in pen 6 laid 107 eggs, five offering to sit. The cock was placed in pen 6. One hen in pen 6 was lame from July 6 to the end of the test; one in pen 5 was injured in the back on July 22, and died August 4. This test closed August 25.

Foods consumed (May 14 to August 25).

Kinds of Food.	Pen 6.	Pen 5.
	Lbs.	Lbs.
Wheat,	179	161½
Oats,	80¾	81¾
Bran,	31½	30¼
Middlings,	31½	30¼
Gluten feed,	31½	30¼
Animal meal,	31½	30¼

Average Weight of Hens (Pounds).

Dates.	Pen 6.	Pen 5.
May 14,	4.91	5.06
June 11,	4.79	4.94
July 16,	4.91	5.09
August 11,	4.94	5.17
August 23,	4.72	5.02

Influence of the Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days,	1,664	1,643
Hen days with cock,	1,768	–
Gross cost of foods,	$5 24	$4 89
Cost per hen day,	$0 0030	$0 0030
Total number of eggs,	629	526
Cost per egg,	$0 0083	$0 0093
Eggs per hen day,	.38+	.33–
Total weight of eggs (pounds),	77.84	64.76
Average weight of eggs (ounces),	1.98	1.97
Dry matter to produce 1 egg (pounds),	.55	.63–
Dry matter consumed per hen day (pounds),	.20	.20
Nutritive ratio,	1:4.8	1:4.7
Sitters,	35	33

Study of these results shows that the cock was without apparent influence upon the egg product of these fowls. The differences are very small, too insignificant to have much weight, even if in both trials of the same nature. When we note, however, that in one trial the balance was very slightly in favor of the set of fowls with which the cock was kept, and that in the other trial it was with the fowls kept without the cock, we must conclude that the results prove neither benefit nor injury due to the presence of the male. In one respect only is there agreement in the results of the two trials; the average weight of the eggs from the hens with which a male was kept was slightly the greater in both trials. It seems not impossible that this effect may be due to the fact that the eggs had been fertilized. The difference is, however, exceedingly small, and would be wholly without significance to the producer of eggs for market or for table use.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

The work of the past season has been along the lines indicated in a previous report, so far as time and circumstances would permit. It has seemed desirable to give especial attention to the immediate needs of the citizens of this Commonwealth, as indicated by the extensive correspondence, from which one is enabled to gain a pretty clear idea of the insects especially troublesome, and upon which help is needed, from year to year. The work on the gypsy and brown-tail moths has demanded a large amount of time, not only in frequent inspections of the field work in the infested territory, but also in planning and directing the scientific part of the work.

A monograph of the plume-moths (*Pterophoridæ*) of North America was prepared and published in the last college report, and a revised edition was issued in July as a special bulletin from this station. Such monographs are absolutely essential as foundation work in economic entomology. I am now at work, when other duties permit, on a similar monograph of the two remaining families of the *Pyralidæ*. Mr. Cooley's monograph on the genus *Chionaspis*, a group of very pernicious scale insects, is now quite far advanced, and will soon be ready for publication.

THE SAN JOSÉ SCALE.

This insect has now unfortunately become established in various parts of the State, and has been sent here for determination during the past season more frequently than any other. This pest, as well as several other injurious scale insects, has been brought into the State and distributed among our fruit growers on nursery stock; and, unless present in large numbers, they are liable to be entirely overlooked, both by the nurseryman and the purchaser, but when they are discovered, not only does the purchaser suffer from the loss of his trees, but the nurseryman is sure to lose his trade. As a result, some of our more progressive dealers in nursery stock, by my advice, have built fumigating houses, and treat all stock received and sent out, with hydro-cyanic acid gas.

Many of the other States have enacted laws for the regular examination of their nurseries, and also prohibiting the introduction of nursery stock that has not been examined by an expert entomologist, appointed for that purpose by the State from which the stock was shipped, and accompanied by his certificate of examination. This has shut out the trade of our nurserymen more or less from all those States where such laws exist, and, at the same time, leaves Massachusetts as a dumping ground for the infested nursery stock of other States. It is evident, therefore, that we need some law to protect us against the introduction of the San José scale and other injurious insects.

The Grass Thrips.

The amount of damage to grass done by this insect has been estimated at more than that of all others combined. This may be an overestimate, but there is no doubt that it is one of the most destructive grass insects in this Commonwealth. Very little has been known of it, beyond the fact that it is very injurious; but no method of dealing with it has been suggested that promised any great degree of success. One of my assistants has worked out its life history and bred it through all of its stages, and will prepare a bulletin on it soon.

The Small Clover-leaf Beetle.

This insect (*Phytonomus nigrirostris*) is very common on the college farm, and is quite destructive to the clover on which it feeds. Its habits and life history will be published when the investigations now being made on it are completed. An allied species, the clover-leaf beetle (*Phytonomus punctatus*), is reported in various parts of this country, and is said to have done a great deal of damage.

The Buffalo Carpet Beetle.

The Buffalo carpet beetle has caused housekeepers more or less trouble for a long time, and the correspondence about this insect has been more extensive during the last ten years than on almost any other. My attention has recently been called to an invasion of this insect in the storehouse of the Geo. Gilbert Manufacturing Company, in Ware, where it was destroying woolen goods. After considering the matter very fully, the owners were advised to close the house as tightly as possible, and fumigate it with hydro-cyanic acid gas. Full instructions were given, in order that no accidents might occur from the use of this deadly gas.

Arsenate of Lead and Bordeaux Mixture.

Arsenate of lead has proved so valuable an insecticide for the destruction of the gypsy moth, as well as other insects, that several correspondents have inquired if it could be used with Bordeaux mixture. A trial was therefore made on several apple trees on my own grounds, with most excellent results and without any injury to the foliage, though the arsenate of lead was used in the proportion of five pounds to one hundred and fifty gallons of water. The fruit of these trees had been badly affected by the scab for several years, but after a single spraying with the above preparation the fruit in the fall was in excellent condition. Experiments will be performed with these substances another year, before giving a detailed account of the work.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, SAMUEL W. WILEY.

Part I. — Report on Official Inspection of Commercial Fertilizers.
Part II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1898.

CHARLES A. GOESSMANN.

The number of licensed manufacturers and dealers in commercial fertilizers and agricultural chemicals during the past year is sixty-one. Thirty-five of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, four in Connecticut, three in Vermont, three in Rhode Island, one in Maine, one in New Jersey, one in Illinois and two in Canada.

The distinct brands of fertilizer, including chemicals, licensed in the State, are two hundred and sixty-four.

Three hundred and seventy-eight samples of fertilizers have thus far been collected in the general market by experienced delegates of the station; of these, three hundred and sixty-three samples were analyzed at the close of November, 1898, representing two hundred and sixty-four distinct brands. The results of these analyses were published for distribution in three bulletins, Nos. 51, 54 and 57, of the Hatch Experiment Station of the Massachusetts Agricultural College, during the months of February, July and November, 1898.

The remaining samples and others coming into our hands before the expiration of the license, May 1, 1899, will be analyzed in due time, and the results published in conformity with our State laws for the regulation of the trade in commercial fertilizers.

The modes of chemical analysis adopted in our examination of fertilizers are, in all essential points, those recommended by the Association of Official Chemists.

For a better understanding and due appreciation of the trade in commercial fertilizers during the past year, the following abstract of our results is here inserted. To arrive at a correct conclusion, it must be borne in mind that only the lowest stated guarantee is legally binding on all sales: —

	1897.	1898.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	3	5
Number with two elements above the highest guarantee,	2	17
Number with one element above the highest guarantee,	60	77
Number with three elements between the lowest and highest guarantee,	69	85
Number with two elements between the lowest and highest guarantee,	63	93
Number with one element between the lowest and highest guarantee,	16	54
Number with two elements below the lowest guarantee,	6	19
Number with one element below the lowest guarantee,	29	90
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	3	5
Number with one element above the highest guarantee,	10	24

	1897.	1898.
Number with two elements between lowest and highest guarantee,	13	25
Number with one element between lowest and highest guarantee,	12	17
Number with two elements below the lowest guarantee,	3	2
Number with one element below the lowest guarantee,	6	8
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	10	18
Number between lowest and highest guarantee,	13	23
Number below the lowest guarantee,	1	15

A comparison of the above-stated results of our inspection during the years 1897 and 1898 shows no material differences regarding the general character of the fertilizers sold in our market. In a few cases it became our duty to communicate with the manufacturers, and ask for an explanation. Imperfect mixing proved in most of these cases the cause of differences between guarantee and our analysis. As the commercial value of the brand was not materially affected, with only two or three exceptions, the cases were passed over, after a satisfactory explanation from the party interested.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the successful raising of farm and garden crops congenial to climate and soil. The fact that the most important essential articles of plant food, as nitrogen, potash and phosphoric acid, are freely offered for sale in our markets in forms suitable to change the manurial refuse of the farm as stable manure and vegetable compost into complete manures for the crops to be raised, deserves the most serious attention of farmers. *To render the stated waste products of the farm in a higher degree efficacious as a manure supply cannot be otherwise considered than as a most promising step in the direction of an economical supply of plant food for the production of farm and garden crops.*

As the manufacturer at best can only prepare his special or so-called complete fertilizers on general lines, not knowing the particular character and condition of the soil which receives them, it becomes the business of the farmer to make his selection with due care. An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

As the physical conditions and chemical resources of soils in available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised in preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station, at Amherst, Mass.

In making choice from among the so-called complete fertilizers, two points in particular seem to be worth remembering. *First*, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to the cost per ton; *mere trade names are no guarantee of fitness*. High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. *Second*, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

Valuation of Commercial Fertilizers.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of the three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.	Ammoniate.
Nitrate of soda.	Castor pomace.
Muriate of potash.	Linseed meal.
Sulphate of potash.	Dried blood.
Cotton-seed meal.	Dried ground meat.
Dry ground fish.	Bone and tankage.
Azotin.	Plain superphosphates, etc.

which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in the form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897 and 1898: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 and 1898 (Cents per Pound).

	1897.	1898.
Nitrogen in ammonia salts,	13.5	14.0
Nitrogen in nitrates,	14.0	13.0
Organic nitrogen in dry and fine ground fish, meat blood, and in high-grade mixed fertilizers,	14.0	14.0
Organic nitrogen in cotton-seed meal,	12.0	12.0
Organic nitrogen in fine bone and tankage,	13.5	13.5
Organic nitrogen in medium bone and tankage,	11.0	10.0
Phosphoric acid soluble in water,	5.5	4.5
Phosphoric acid soluble in ammonium citrate,	5.0	4.0
Phosphoric acid in fine bone and tankage,	5.0	4.0
Phosphoric acid in cotton-seed meal, castor pomace, wood ashes and fine-ground fish,	5.0	4.0
Phosphoric acid in coarse bone and tankage,	2.5	3.5
Phosphoric acid insoluble (in ammonium citrate) in mixed fertilizers,	2.0	2.0
Potash as sulphate (free from chlorides),	5.0	5.0
Potash as muriate,	4.5	4.25

From these figures it is apparent that some of the best forms of nitrogen and phosphoric acid have suffered, as a rule, a reduction in cost, as compared with preceding years.

For further details I have to refer to preceding annual reports.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties.

The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home composition, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1898, to May 1, 1899), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Butchers' Rendering Association, Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

H. J. Baker & Bro., New York, N.Y.: —
- Standard Un X Ld Fertilizer.
- Strawberry Manure.
- Potato Manure.
- Complete Cabbage Manure.
- A. A. Ammoniated Superphosphate.
- Complete Manure for General Use.
- Grass and Lawn Dressing.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport Conn.: —
- Complete Fertilizer.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash, H B.
- Fish Scrap No. 2, H B.

Bowker Fertilizer Co , Boston, Mass.: —
- Stockbridge Special Manures.
- Hill and Drill Phosphate.
- Farm and Garden Phosphate.
- Lawn and Garden Dressing.
- Fish and Potash.
- Potato and Vegetable Manure.
- Potato Phosphate.
- Market Garden Manure.
- Sure Crop Phosphate.
- Gloucester Fish and Potash.
- High-grade Fertilizer.
- Essex Fertilizer.
- Bone and Wood Ash Fertilizer.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.

William E. Brightman, Tiverton, R. I.: —
- Potato and Root Manure.
- Phosphate.
- Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- X. L. Superphosphate.
- Potato Manure.
- B. D. Sea Fowl Guano.
- Complete Manures.
- Fish and Potash.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.
- Corn Phosphate.
- Muriate of Potash.
- Nitrate of Soda.
- Dissolved Bone.
- Fine-ground Bone.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's B Special.
- Church's C Standard.
- Church's D Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer G. G. Brand.

Clark's Cove Fertilizer Co. — *Con.*
Great Planet Manure.
Potato Fertilizer.
King Philip Guano.
Potato Manure.
Fish and Potash.
White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass.: —
Superphosphate.
Potato Phosphate.
Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
High-grade Potato Fertilizer.
Tobacco and Onion Fertilizer.
High-grade Ammoniated Bone Superphosphate.
Gold Brand Excelsior Guano.
Fish Guano and Potash.
Bay State Phosphate.
Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
Ammoniated Bone Superphosphate.
Potato, Hop and Tobacco Phosphate.
Ammoniated Wheat and Corn Phosphate.
New Rival Ammoniated Superphosphate.
Vegetable Bone Superphosphate.
General Crop Phosphate.
Universal Grain Grower.
Special Potato Manure.
New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Superphosphate.
Potato Fertilizer.
Concentrated Phosphate.
Fertilizer.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
Animal Fertilizer.
Potato and Root Crop Manure.
Tobacco Grower.
Blood, Bone and Potash.
Special Formula.
Fine-ground Bone.
Muriate of Potash.
Nitrate of Soda.
Farm Favorite.

John C. Dow & Co., Boston, Mass.: —
Nitrogenous Superphosphate.
Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Liquid Plant Food.

W. E. Fyfe & Co., Clinton, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Northern Corn Special.
General Fertilizer.
Vegetable, Vine and Tobacco Fertilizer.
Garden Special.
Grass and Oats Fertilizer.

Thomas Hersom & Co., New Bedford, Mass.: —
Bone Meal.
Meat and Bone.

Edmund Hersey, Hingham, Mass.: —
Ground Bone.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Celebrated Onion Fertilizer.
Lister's Success Fertilizer.
Lister's Special Potato Fertilizer.
Lister's Special Tobacco Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
Bone Fertilizer for Corn and Grain.
Animal Fertilizer.
Potato Phosphate.
Bone and Potash.
Lawn Dressing.
Tobacco Manure.
Fruit and Vine Fertilizer.
Market-garden Fertilizer.
Ground Bone.

Lowe Bros., & Co., Fitchburg, Mass.: —
Tankage.

F. R. Lalor, Dunville, Ontario, Can.: —
Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Bone Manures.
- Superphosphates.
- Special Crop Manures.
- Sulphate of Potash.
- Double Manure Salts.
- Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can.: —
- Unleached Hard-wood Ashes.

McQuade Bros., West Auburn, Mass.: —
- Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y.: —
- Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
- Complete Fertilizers.
- Ammoniated Bone.
- Market-garden Manure.
- Potato Phosphate.
- Fish and Potash.
- Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
- Wheat and Corn Producer.
- Potato, Tobacco and Hop Fertilizer.
- Niagara Triumph.

Packers Union Fertilizer Co., New York, N. Y.: —
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Animal Corn Fertilizer.
- Potato Manure.
- Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass.: —
- Soluble Pacific Guano.
- Special Potato Manure.
- Nobsque Guano.
- High-grade General Fertilizer.
- Grass and Grain Fertilizer.
- Fish and Potash.
- Pacific Guano with 10 per cent. Potash.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Star Brand Superphosphate.

Parmenter & Polsey Fertilizer Co. — *Con.*
- Special Potato.
- Strawberry and Small Fruits.
- Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- P. & P. Potato Fertilizer.

A. W. Perkins & Co., Rutland, Vt.: —
- Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
- Pioneer.
- Potato Fertilizer.
- Superphosphate, I.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Market-garden Manure.
- Fish and Potash.
- Grass Fertilizer.
- Corn Manure.
- Potato Phosphate.
- Climax Phosphate.
- Pure Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- Kainit.
- Dissolved Bone-black.

Benjamin Randall, East Boston, Mass.: —
- Market-garden Fertilizer.
- Farm and Field.
- Ground Raw Bone.

Read Fertilizer Co., New York, N. Y. (H. D. Foster, general agent): —
- Standard Fertilizer.
- High-grade Farmers' Friend.
- Practical Potato Special.
- Vegetable and Vine.
- Fish, Bone and Potash.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

The Rogers & Hubbard Co., Middletown, Conn.: —
Hubbard's Soluble Potato Manure.
Hubbard's Soluble Tobacco Manure.
Hubbard's Fairchild's Formula for Corn and General Crops.
Hubbard's Grass and Grain Fertilizer.
Hubbard's Oats and Top-dressing Fertilizer.
Hubbard's Pure Raw Knuckle Bone Flour.
Hubbard's Strictly Pure Fine Bone.
Hubbard's Fertilizer for all Soils and all Crops.

Russia Cement Co., Gloucester, Mass.:—
X X X Fish and Potash.
High-grade Superphosphate.
Corn, Grain and Grass Manure.
Potato, Root and Vegetable Manure.
Odorless Lawn Dressing.
Potato Fertilizer.
Dry Ground Fish.
Special Manure for Carnations.

Lucien Sanderson, New Haven, Conn.:—
Formula A.
Blood, Bone and Meat.
Dissolved Bone-black.
Nitrate of Soda.
Sulphate of Potash.
Muriate of Potash.
Sanderson's Old Reliable Superphosphate.
Sanderson's Potato Manure.

Edward H. Smith, Northborough, Mass.: —
Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
Ground Bone.

Standard Fertilizer Co., Boston, Mass.:—
Standard Fertilizer.
Standard Guano.
Complete Manure.
Special for Potatoes.

C. F. Sturtevant, Hartford, Conn.: —
Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.
Bay State Special.

Andrew H. Ward, Boston, Mass.: —
Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
Complete Manure.

D. Whithead, Lowell, Mass.: —
Champion Garden Fertilizer.
Bone Meal.

The Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Tobacco Manure.
High-grade fish and potash.
Dry Ground Fish Guano.
Fish and Potash 1895 Brand.

Williams and Clark Fertilizer Co., Boston, Mass.: —
Ammoniated Bone Superphosphate.
Potato Phosphate.
High-grade Special.
Fine Wrapper Tobacco Grower.
Royal Bone Phosphate.
Corn Phosphate.
Potato Manure.
Grass Manure.
Fish and Potash.
Prolific Crop Producer.
Onion Manure.
Bone Meal.
Dry Ground Fish.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
High-grade Corn Fertilizer.
High-grade Potato Manure.
Superior Truck Fertilizer.
High-grade Fruit Fertilizer.
High-grade Grass and Oats Fertilizer.

A. L. Warren, Northborough, Mass.: —
Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
Fine-ground Bone.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Wood Ashes, Condition of Trade, etc.
3. Notes on Fertilizers for Pot Cultivation and Greenhouses.
4. Observations regarding the Action of Acid and Basic Phosphates on the Availibility of the Nitrogen in Blood, Steamed Leather and Leather Scraps.
5. Notes on the Determination of the Available Phosphoric Acid in the Soil.
6. Analyses of Drainage Waters obtained in Connection with Some Field Experiments carried on upon the Grounds of the Station.

1. Analyses of Materials sent on for Examination.

The number of substances tested in this connection amount to several hundred. The results of our examination are already published in detail in Bulletins 51, 54 and 57 of the Hatch Experiment Station of the Massachusetts Agricultural College, in connection with the results of the official inspection of commercial fertilizers collected from original packages by an efficient delegate of the station.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for the analysis. Our publication of the results refers merely to the locality they come from, to avoid misunderstandings. The work carried on in this connection is growing from year to year in importance.

A large proportion of commercial manurial substances consist of by or waste products of various industries. The composition and general character of these materials depend on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason, arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers, to the full extent of the resources placed at the disposal of the officer in charge of this work.

These investigations are carried on free of charge to farmers of the State, and as far as the financial resources of the laboratory admit. The examination of the materials is, as a rule, carried on in the order they arrive at the station, and the results are considered public property.

The following statement of the names of the different articles sent on and thus far analyzed may suffice here to convey some more definite idea concerning the general character of the work: —

Materials sent on, Dec. 1, 1897, to Dec. 1, 1898.

Air-dried potatoes,	9	Peat,	1
Acid phosphate,	2	Nitrate of soda,	3
Ashes from cremation of garbage,	1	Sulphate of ammonia,	1
Bleachery refuse,	2	Sulphate of potash and magnesia,	1
Broom corn seed,	1	Sulphate of potash,	2
Cotton-seed meal,	2	Sweet clover hay,	3
Compound fertilizers,	21	Sulphate of magnesia,	1
Cremation ashes,	1	Soya bean refuse,	1
Dissolved bone-black,	1	Starch,	2
Fodder material,	1	Sewage,	1
Ground bone,	9	Soil,	12
Ground fish,	1	Silicate of potash,	1
Hop refuse,	1	Tankage,	3
Lime-kiln ashes,	2	Tobacco stems,	1
Liquid fertilizer,	1	Tobacco refuse,	1
Manure,	12	Teopik fibre,	1
Marl,	1	Wood ashes,	79
Muriate of potash,	3	Wool waste,	1
Muck,	5	Whale-bone scrapings,	1
Minerals,	3	Vat deposit,	1
Oxalic acid,	1		

A few of the more important of the above-stated materials, as wood ashes, etc., are discussed more at length in subsequent pages.

2. Notes on Wood Ashes.

Wood ashes for manurial purposes are in our State subject to official inspection, and dealers in that commodity have to secure a license to sell in our State before they can legally advertise their articles for sale. This circumstance makes it obligatory on the dealers to state the amount of potash and of phosphoric acid they guarantee in these materials, and to fasten that statement upon the package or car, etc., which contains them.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered, in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both, as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid. Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and the general character of foreign matters are apt to seriously affect the weight of a given measure.

During the past year (1898) 40.1 per cent. of the materials sent on for analysis consisted of wood-ash samples; during the preceding year (1897) they amounted to 40 per cent.

The general character of the wood ashes sold during the stated years may be judged from the following classified statement of our results: —

		No. of Samples. 1897.	1898.
Moisture from 1 to 3 per cent.,		10	9
Moisture from 3 to 6 per cent.,		8	6
Moisture from 6 to 10 per cent.,		13	20
Moisture from 10 to 15 per cent.,		19	22
Moisture from 15 to 20 per cent.,		11	16
Moisture from 20 to 30 per cent.,		10	6
Moisture above 35 per cent.,		1	–
Potassium oxide above 8 per cent.,		3	4
Potassium oxide from 7 to 8 per cent.,		8	6
Potassium oxide from 6 to 7 per cent.,		21	8
Potassium oxide from 5 to 6 per cent.,		28	22
Potassium oxide from 4 to 5 per cent.,		10	25
Potassium oxide from 3 to 4 per cent.,		3	11
Potassium oxide below 3 per cent.,		–	3
Phosphoric acid above 2 per cent.,		4	6
Phosphoric acid from 1 to 2 per cent.,		45	60
Phosphoric acid below 1 per cent.,		24	13
Average per cent. of calcium oxide (lime),		34.29	33.60
Per cent. mineral matter insoluble in diluted hydrochloric acid, from —	below 5,	–	1
	6 to 10,	10	16
	10 to 15,	30	31
	15 to 20,	15	15
	20 to 30,	3	13
	above 30,	1	-

As the majority of dealers in wood ashes guarantee from 4.5 to 6 per cent. of potassium oxide in their articles, it will be seen that a large number of the samples are below even the lowest guarantee; showing, on the whole, that the quality of wood ashes sold in 1898 as a potash source has been inferior, when compared with the preceding year. Whether this circumstance is due to a general decline of the article or to the management of any particular importer or dealer is difficult to decide on our part, as long as farmers do not state the name of the party from whom they have bought, or the cost per ton of the ashes they send on for examination.

It is most desirable to ascertain whether the general character of the wood ashes is gradually declining from natural causes, or whether some parties are handling inferior goods. All interested in the solution of this question will confer a favor on us by sending with their samples of wood ashes the names of the party from whom they bought the article, and state the price per ton asked at the nearest depot for general distribution.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

3. Notes on Fertilizers suitable for raising Plants in Pots and Greenhouses.

The interest in raising plants in pots and under glass in greenhouses, by the aid of commercial fertilizers, is gradually increasing, judging from numerous applications for information.

The following analyses represent two samples of fertilizers recommended for that purpose; they were sent on for a general analysis by parties interested in the matter: —

1. Plant Food in Pellet Form, sent on from Newtonville, Mass.

	Per Cent.
Moisture,	3.39
Organic and volatile matter,	41.15
Ash constituents,	58.85
Water soluble material,	82.40
Insoluble residue (in water),	17.60
Total phosphoric acid,	16.59
Soluble phosphoric acid,	14.58
Reverted phosphoric acid,	1.67
Insoluble phosphoric acid,	.34
Potassium oxide, total,	7.96
Potassium oxide, water soluble,	7.63
Sodium oxide,	6.19
Calcium oxide,	4.04
Magnesium oxide,	5.30
Chlorine,	6.05
Sulphuric acid (SO_3),	17.17
Total nitrogen,	7.65
Nitrogen as ammoniates,	7.06
Nitrogen as nitrates,	.50
Nitrogen as organic matter,	.09
Insoluble matter in dilute hydrochloric acid (clay),	14.33

Water solution strongly acid.

2. *Liquid Fertilizer sent on from Natick, Mass.*

	Per Cent.
Moisture,	90.46
Solid residue,	9.54
Phosphoric acid,	1.24
Potassium oxide,	2.79
Sodium oxide,	1.67
Calcium oxide,	1.82
Magnesium oxide,	.07
Chlorine,	.02
Sulphuric acid (SO_3),	–
Total nitrogen,	1.12
Nitrogen as ammoniates,	.39
Nitrogen as nitrates,	.73
Reaction strongly acid.	

The importance of the interests involved induced the writer some years ago to enter upon a series of experiments, to assist in the development of a more efficient system of manuring several important industrial crops, fruits and garden vegetables. The first results of that investigation are published in the eleventh and twelfth reports of the director of the Massachusetts State Agricultural Experiment Station, to which I have to refer for details. Those of later years are contained in the annual report of the Hatch Experiment Station of the Massachusetts Agricultural College for 1896 and 1897.

In the course of my discussion of the lessons to be derived from the above-stated experiment in field and vegetation house, it was recommended to observe the following rules : —

1. To avoid an accumulation of half-decayed vegetable matter in the soil, and to enrich the latter in the desired direction by means of concentrated chemical manures.

2. To change, wherever practicable, from season to season the position of the various crops, to favor the destruction of parasites and to economize the inherent sources of plant food.

3. To avoid an accumulation of salines in the soil, not called for by the crops, or considered injurious to the chemical or physical properties of the soil.

4. To prevent a marked acidity of the soil, by a periodical application of air-slacked lime, wood ashes, etc.

5. To select the various commercial forms of nitrogen, and potash in particular, with special reference to the kind and the desired character of the crop to be raised.

6. To use as a general fertilizer a mixture of two parts of available potassium oxide, one part of available nitrogen and one part of available phosphoric acid, in such quantities per acre as the conditions of the soil and composition of the crop to be raised called for; allowing, for the composition of one thousand pounds of green garden vegetables, on an average: —

	Pounds.
Nitrogen,	4.01
Phosphoric acid,	1.90
Potassium oxide,	3.90

On account of the frequent cultivation of beans and peas as garden crops, a fertilizer of the following composition suggested itself to me: —

	Parts.
Available nitrogen,	1
Available potash,	2
Available phosphoric acid,	1

More recent observations confirm the advisability of the previously stated rules in a general way; yet they also emphasize the fact that, wherever the quality of the crop controls its economical and commercial value, it seems advisable that care should be taken to secure the exclusion of an accumulation of soluble saline substances not called for by the crop. This circumstance deserves particular attention in cultivation under glass, where the body of the soil is limited, and the removal of such substances by percolation to the lower layers offers but little chance of relief.

In our experiments above described this view of the question of supplying plant food in the greenhouse has aided us in selecting a series of concentrated chemical manures, which for the above reason are now recommended for patronage: —

NAME OF SUBSTANCE.	Potassium Oxide (Per Cent.).	Phosphoric Acid (Per Cent.).	Nitrogen (Per Cent.).
High-grade muriate of potash,	50.00	-	-
High-grade sulphate of potash,	50.20	-	-
Potash-magnesia sulphate,	24.32	-	-
Carbonate of potash-magnesia,	18.48	-	-
Phosphate of potash,	32.56	35.70	-
Dissolved bone-black,	-	13.88	-
Odorless phosphate, phosphatic slag,	-	18.42	-
Double superphosphate,	-	47.80	-
Phosphate of ammonia,	-	43.86	10.37
Dried blood,	-	4.02	10.00
Nitrate of soda,	-	-	14.28
Sulphate of ammonia,	-	-	19.59

As the local conditions of the soil and the composition of the individual characteristics of the plants to be raised deserve especial attention, when selecting from the above-stated commercial manurial substances the constituents for the fertilizer mixtures to be used, it cannot be considered judicious to recommend any particular combination as being unfailing and best in all cases. For this reason it has been thought best to state in this connection, as a mere matter of illustration, a few combinations of manurial substances which served us well, as may be noticed from a few preceding annual reports, — State Experiment Station, 1893, pages 241 to 261; and 1894, pages 274 to 285.

The amount of fertilizer recommended per acre, under fair conditions of the soil, contains: —

	Pounds.
Available nitrogen,	60
Available phosphoric acid,	60
Available potash,	120

Some Combinations of High-grade Substances for Use in Garden, Greenhouse and Pots.

1. Nitrate of soda.
   High-grade sulphate of potash.
   Dissolved bone-black.

2. Sulphate of ammonia.
   High-grade sulphate of potash.
   Dissolved bone-black.

3. Dried blood.
   High-grade sulphate of potash.
   Dissolved bone-black.

4. Nitrate of soda.
   Muriate of potash.
   Dissolved bone-black.

Mixtures of muriate of potash and sulphate of ammonia have proved in our experience in many cases objectionable, on account of a mutual decomposition into chloride of ammonia and sulphate of potash.

4. Observations with Dried Blood and Two Kinds of Leather Refuse as the Sources of Nitrogen for growing Rye in Presence of Acid and of Alkaline Phosphates.

In a preceding report an experiment has been briefly described in which dried blood has been compared with leather refuse as a nitrogen source for growing plants, when used in connection with double phosphate and muriate of potash. The differences of the crops raised were more marked with reference to the yield of the straw than to that of the grain. (For details, see annual report of the Massachusetts State Agricultural Experiment Station for 1894, pages 283–285.) It seemed advisable to repeat the experiments, with such modifications as experience suggested, to secure, if possible, *more decisive results*, and to ascertain whether the degree of availability of the nitrogen contained in the dried blood and in the leather refuse would not be more strikingly modified by using *alkaline phosphates* instead of *acid phosphates* as the phosphoric acid source.

The following course was adopted. Winter rye was again selected for the observation. The soil used was taken from the same locality, at eighteen inches below the surface, and freed from coarse materials by repeated screening through a sand screen, as in the first experiment. The fertilizers used were in each case carefully distributed throughout the entire body of the soil. The boxes were the same which had been used in the preceding experiments, containing from seventy-five to eighty pounds of soil, having a depth of eighteen inches.

Six boxes were employed in the experiment; three served for the trial with acid phosphate, — dissolved bone-black; and three with an alkaline phosphate, — phosphatic slag meal. The following mixtures of fertilizers were used (weights are stated in grams; thirty grams equal to one ounce): —

First Lot, Nos. 1, 3 and 5.

Box 1.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Dried blood,	40.22

Box 3.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 5.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Raw-leather waste,	56.64

Second Lot, Nos. 2, 4 and 6.

Box 2.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Dried blood,	40.22

Box 4.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 6.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Raw-leather waste,	56.64

The Seed. — Winter rye was planted in all boxes Oct. 2, 1894. The young plants came up uniformly in all boxes October 5. They reached a height of from five to six inches before frost set in. After being fully developed, they were reduced in all the boxes to a corresponding number, as in the first experiment.

The watering of the soil was partly by subirrigation and partly by surface application, maintaining as far as practicable the moisture of the soil from 15 to 18 per cent. during the growing season. The experiment was conducted with a view to expose the soil to the unrestricted influence of the local temperature of the various seasons. A layer of snow served as protection to the young growth during severe spells of frost in winter.

The manurial substances used consisted of high-grade sulphate of potash, dissolved bone-black, phosphatic slag meal, dried blood, Philadelphia tankage (a steamed leather), and ground sole leather waste. The amount of nitrogen and potassium oxide applied was the same in each case, while the amount of total phosphoric acid applied in case of the phosphatic slag meal was one-fourth more than in the case of the dissolved bone-black, which is practically all soluble in water.

Composition of the Manurial Substance used, with Reference to Potash, Phosphoric Acid and Nitrogen (Per Cent.).

	Potassium Oxide.	Phosphoric Acid.	Nitrogen.
Sulphate of potash,	50.20	-	-
Dissolved bone-black,	-	14.00	-
Phosphatic slag meal,*	-	18.40	-
Dried blood,	-	4.00	10.00
Philadelphia tankage (steamed leather),	-	-	7.80
Ground leather waste,	-	-	7.02

* Calcium oxide, 48.6 per cent.

They grew at a similar rate during spring until the latter part of April, when those which had received dried blood as nitrogen source (boxes 1 and 2) became more stalky, developing more and broader leaves than the plants in boxes 3, 4, 5 and 6. This difference in their growth became more marked as the season advanced.

The following statement gives the average height of the plants at various stages of observation (inches): —

	May 1.	May 9.	May 20.	June 1.
Box 1,	8.0	21.5	34.0	50.0
Box 3,	7.0	16.5	24.0	32.0
Box 5,	6.0	14.0	22.5	30.5
Box 2,	9.0	26.0	38.0	56.5
Box 4,	7.0	17.5	25.0	32.5
Box 6,	7.0	17.5	26.0	35.0

The plants in all boxes began blooming about the same time, the first week of June; they were harvested the first week of July. There was no marked difference in regard to time of maturing. The general character of the matured growth will be seen from the subsequent statement of the weights of the average plant in each case (grams) : —

	Box 1.	Box 3.	Box 5.	Box 2.	Box 4.	Box 6.
Moisture, ...	8-9	8-9	8-9	8-9	8-9	8-9
Total plant, ...	57.87	26.02	28.80	115.99	30.27	36.21
Kernels, ...	12.77	5.43	5.80	28.89	6.18	9.75
Chaff and straw, . . .	45.12	20.69	23.00	87.10	24.09	26.46
One hundred kernels, . .	1.58	1.44	1.48	1.79	1.58	1.62

The plants were in all cases cut two inches above their roots. As it was of interest to know the amount of nitrogen in the kernels of the highest and lowest weights, a nitrogen determination of the kernels obtained in boxes 1 and 3, and 2 and 4 was carried out. The analyses gave the following results : —

No. of Box.	Per Cent. Nitrogen.	Fertilizing Elements Used.
1, ...	1.84	Dried blood, dissolved bone-black.
3, ...	1.91	Philadelphia tankage, dissolved bone-black.
2, ...	2.31	Dried blood, phosphatic slag.
4, ...	2.19	Philadelphia tankage, phosphatic slag.

Fodder Analyses of Rye Samples (Kernels) as far as Material on Hand sufficed for a Complete Analysis. Samples grown in Boxes 1, 2, 3 and 4 (Per Cent.).

	Box 1.	Box 2.	Box 3.	Box 4.
Moisture, ...	10.45	9.92	4.87	8.50
Dry matter, ...	89.55	90.08	95.13	91.50
	100.00	100.00	100.00	100.00

Analysis of Dry Matter.

	Box 1.	Box 2.	Box 3.	Box 4.
Fat,	2.05	2.00	2.12	1.97
Protein,	11.50	14.44	11.94	13.69
Cellulose,	1.55	1.65	1.65	1.62
Ashes,	1.95	1.52	2.20	1.44
Carbohydrates,	82.95	80.39	82.09	81.28
	100.00	100.00	100.00	100.00

Judging from the results obtained in connection with the described experiment the following conclusions suggest themselves: —

Conclusions. — The alkaline phosphate (phosphatic slag meal) has under fairly corresponding conditions increased the availability of the nitrogen contained in steamed leather, in leather scraps and in dried blood in a higher degree than the acid phosphate. The influence is apparent alike in the general character of the entire plant and in the composition of the kernels. The difference in the relative agricultural value of both articles as nitrogen sources remains, however, the same; for leather in any form, without a previous destruction of the tanning principle, tannin, is worthless for manurial purposes.

5. Contribution to the Determination of the Available Phosphoric Acid in Soils under Cultivation.

The fact that agricultural chemists have thus far failed to point out any mode of soil analysis as reliable, by which the amount of phosphoric acid available to crops can be ascertained, is pretty generally recognized. Attempts are not wanting to solve this important question. Among the well-known investigations in that direction are those of Dr. B. Deyer (1894). Results of later years obtained in this connection upon soils of well-known history at Rothamsted in England are pronounced very encouraging by Dr. Gilbert. The American Association of Official Chemists has during the past year entered upon a systematic investigation regarding the best course to be adopted to determine the available phosphoric acid; in this work the writer has taken some part. A compilation of the contributions to these more recent experiments is to be published soon by the United States Department of Agriculture.

Our local observations at Amherst are briefly described in a few subsequent pages upon a field which had been under careful observation for five years, 1890–95. The following brief abstract of the management of the field work shows the condition of the soil which served for our investigation: —

Field F.

The field selected for this purpose is 300 feet long and 137 feet wide, running on a level from east to west. Previous to 1887 it was used as a meadow, which was well worn out at that time, yielding but a scanty crop of English hay. During the autumn of 1887 the sod was turned under and left in that state over winter. It was decided to prepare the field for special experiments with phosphoric acid by a systematic exhaustion of its inherent resources of plant food. For this reason no manurial matter of any description was applied during the years 1887, 1888 and 1889.

The soil, a fair sandy loam, was carefully prepared every year by ploughing during the fall and in the spring, to improve its mechanical condition to the full extent of existing circumstances. During the same period a crop was raised every year. These crops were selected, as far as practicable, with a view to exhaust the supply of phosphoric acid in particular. Corn, Hungarian grass and leguminous crops (cow-pea, vetch and serradella) followed each other in the order stated.

1890. — The field was subdivided into five plats, running from east to west, each twenty-one feet wide, with a space of eight feet between adjoining plats.

The manurial material applied to each of these five plats contained, in every instance, the same form and the same quantity of potassium oxide and of nitrogen, while the phosphoric acid was furnished in each case in the form of a different commercial phosphoric-acid-containing article, namely, phosphatic slag, Mona guano, Florida phosphate, South Carolina phosphate (floats) and dissolved bone-black. The market cost of each of these articles controlled the quantity applied, for each plat received the same money value in its particular kind of phosphate.

Analyses of Phosphates used.

[I., phosphatic slag; II., Mona guano; III., Florida phosphate; IV., South Carolina phosphate; V., dissolved bone-black.]

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture,	.47	12.52	2.53	.39	15.96
Ash,	–	75.99	89.52	–	61.46
Calcium oxide,	46.47	37.49	17.89	46.76	–
Magnesium oxide,	5.05	–	–	–	–
Ferric and aluminic oxides,	14.35	–	14.25	5.78	–
Total phosphoric acid,	19.04	21.88	21.72	27.57	15.82
Soluble phosphoric acid,	–	–	–	–	12.65
Reverted phosphoric acid,	–	7.55	–	4.27	2.52
Insoluble phosphoric acid,	–	14.33	–	23.30	.65
Insoluble matter,	4.39	2.45	30.50	9.04	6.26

The following fertilizer mixtures have been applied annually to all the plats, with the exception of Plat 3, which received in 1890 ground apatite and in 1891 no phosphate whatever: —

Plats.	Annual Supply of Manurial Substances.	Pounds.
Plat 1 (south, 6,494 square feet),	Ground phosphatic slag,	127
	Nitrate of soda,	43
	Potash-magnesia sulphate,	58
Plat 2 (6,565 square feet),	Ground Mona guano,	128
	Nitrate of soda,	43½
	Potash-magnesia sulphate,	59
Plat 3 (6,636 square feet),	Ground Florida phosphate,	129
	Nitrate of soda,	44
	Potash-magnesia sulphate,	59
Plat 4 (6,707 square feet),	South Carolina phosphate,	131
	Nitrate of soda,	44½
	Potash-magnesia sulphate,	60
Plat 5 (6,778 square feet),	Dissolved bone-black,	78
	Nitrate of soda,	45
	Potash-magnesia sulphate,	61

The phosphatic slag, Mona guano, South Carolina phosphate and Florida phosphate were applied at the rate of 850 pounds per acre; dissolved bone-black at the rate of 500 pounds per acre. Nitrate of soda was applied at the rate of 250 pounds per acre and potash-magnesia sulphate at the rate of 390 pounds per acre.

Potatoes were raised upon the plats in 1890; in 1891 winter wheat was employed (for details see ninth annual report); in 1892 serradella was the crop experimented with (see tenth annual report); and in 1893 a variety of Dent corn, Pride of the North (see eleventh annual report).

1894. — During the preceding season it was decided to ascertain the after-effect of the phosphoric acid applied during previous years by excluding it from the fertilizer applied. In addition, to secure the full effect of the phosphoric acid stored up, the potassium oxide and nitrogen were increased one-half, as compared with preceding seasons. A grain crop (barley) calling for a liberal amount of phosphoric acid was chosen for the trial. The field was ploughed April 17, the fertilizer being applied broadcast April 20, and harrowed in. Below is given a statement of fertilizer applied: —

Plat 1 (6,494 square feet),	64½ pounds of nitrate of soda. 87 pounds of potash-magnesia sulphate.
Plat 2 (6,565 square feet),	65¼ pounds of nitrate of soda. 88 pounds of potash-magnesia sulphate.
Plat 3 (6,636 square feet),	66 pounds of nitrate of soda. 89 pounds of potash-magnesia sulphate.
Plat 4 (6,707 square feet),	66¾ pounds of nitrate of soda. 90 pounds of potash-magnesia sulphate.
Plat 5 (6,778 square feet),	67½ pounds of nitrate of soda. 90½ pounds of potash-magnesia sulphate.

Yield of Crop (1894).

Plats.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1,	490	169	221	34.49	65.51
Plat 2,	405	148	251	34.07	65.93
Plat 3,	290	78	212	26.89	73.11
Plat 4,	460	144	216	31.30	68.70
Plat 5,	390	118	272	30.26	69.74

Summary of Yield of Crop (1890–94).

Plats.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.	1894. Barley.
Plat 1,	1,600	380	4,070	1,660	490
Plat 2,	1,415	340	3,410	1,381	405
Plat 3,	1,500	215	2,750	1,347	290
Plat 4,	1,830	380	3,110	1,469	460
Plat 5,	2,120	405	2,920	1,322	390

Phosphoric Acid applied to and removed from Field.

[Pounds.]

Plats.	1890.		1891.		1892.		1893.		1894.		Total Amount Added.	Total Amount Removed.	Total Amount Remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1,	24.18	2.56	24.18	1.23	24.18	8.95	24.18	7.20	-*	1.92	96.72	21.86	75.86
Plat 2,	28.01	2.36	28.01	1.19	28.01	7.50	28.01	6.33	-*	1.64	72.04	19.02	53.02
Plat 3,	109.68	2.40	-*	.69	28.01	6.05	28.01	5.95	-*	.76	165.70	15.85	149.85
Plat 4,	36.12	2.93	36.12	1.31	36.12	6.84	36.12	6.68	-*	1.72	144.48	19.84	124.64
Plat 5,	12.34	3.39	12.34	1.22	12.34	6.42	12.34	6.05	-*	1.49	49.36	18.57	30.79

* None.

Conclusions.

From the previous statement of comparative yield we find that the plat receiving dissolved bone-black leads in yield during the first two years, while for the third, fourth and fifth years the plats receiving insoluble phosphates are ahead, phosphatic slag being first, South Carolina floats second and Mona guano third.

Description of Modes of Analysis adopted in our Investigations of Samples of Soil taken from the above-mentioned Five Plats in September, 1894, in the Manner recommended by the Committee of the American Association of Official Chemists, Prof. Harry Snyder of Minnesota, Chairman.

I. — Total Phosphoric Acid.

Ten grams of soil are digested with 100 c.c. of pure hydrochloric acid, of specific gravity 1.115, for ten consecutive hours in a boiling-water bath, shaking once each hour. The stopper of the flask should carry a condensing tube, to prevent evaporation. The material is filtered, and the residue is washed with distilled water until free of acid. The organic matter in filtrate is oxidized with nitric acid and evaporated to dryness on the water bath, finishing on sand bath to complete dryness. The material when cool is taken up with hot water and a few cubic centimeters of hydrochloric acid, and again evaporated to complete dryness. It is taken up as before, filtered and washed thoroughly with cold water, cooled and made up to 500 c.c.

II. — Directions of the Association of Official Agricultural Chemists for the Determination of Available Phosphoric Acid in Soils, Fifth Normal Hydrochloric Acid being used as the Solvent.

1. Determination of Moisture. — Use the official method described in Bulletin 46, page 48, Division of Chemistry, United States Department of Agriculture. Calculate all results to the water free basis.

2. Determination of Phosphoric Acid Soluble in Fifth Normal Hydrochloric Acid. — (*a*) Preliminary treatment: Digest 20 grams of soil with 200 c.c. of fifth normal hydrochloric acid at 40° C. for five hours. Titrate 20 c.c. of the clear filtrate against a standard caustic soda solution, using phenolphthaline for the indicator. From this data calculate the amount of hydrochloric acid necessary to be added, so that the solution will be fifth normal after allowing for the acid neutralized. (*b*) The determination: Weigh out 50 to 100 grams of soil into an Erlenmeyer flask, and add 10 c.c. of acid, corrected for neutralization as directed under (*a*) for every gram of soil used. The flask is corked with a rubber stopper, which carries a thermometer. The flask is then placed in a water bath previously heated to 40° C., and the contents of the flask are thoroughly shaken every half hour during the digestion. The solution is then filtered through a ribbed filter of two thicknesses of paper, refiltering the first portion, if cloudy. The filter should be large enough to receive the entire contents of the flask. Before filtering the contents, the flask should be well shaken. Four hundred to 600 c.c. of the filtrate (at 20° C.) are evaporated to dryness after adding 1 to 3 c.c. of nitric acid. If there is any appreciable amount of organic matter present, the residue is to be carefully charred. Moisten the residue with hydrochloric acid and add 50 to 100 c.c. of distilled water, and then digest. Filter, neutralize with ammonia, add 5 c.c. of strong nitric acid and 15 grams of nitrate of ammonia in solution. Complete the determination according to one of the official methods given for the determination of phosphoric acid, or use the Goss method as given in Circular No. 4 to accompany Bulletin No. 46.

III. — Determination of the Available Phosphoric Acid in Soils by Means of a One Per Cent. Solution of Citric Acid (Dr. B. Deyer).

Preliminary Treatment. — Twenty grams of soil are digested with 200 c.c. of a one per cent. citric acid solution for five hours, at ordinary temperature (18° to 21° C.). The material is filtered and solution is titrated against a standard alkali solution, to determine the amount of acid neutralized by alkalies in the soil. For the estimation of the "available" potash and phosphoric acid, one per cent. citric acid solution has been employed, digesting 100 grams of air-dried soil with 500 c.c. of the solvent, as directed in the preliminary test, corrected for neutralization, for five hours at room temperature. The filtered solution is evaporated to dryness, charred, and the residue abstracted with dilute hydrochloric acid and water. The filtrate from this operation is treated for the determination of phosphoric acid as directed in one of the official methods.

IV. — Determination of the Available Phosphoric Acid in Soils by Means of a Neutral Solution of Citrate of Ammonia.

Ten grams of the soil are digested for one-half hour, at 65° C., with 500 c.c. of strictly neutral solution of citrate of ammonia, specific gravity 1.09. The flask carries a rubber stopper, and is thoroughly agitated every five minutes. At the expiration of thirty minutes, remove flask from bath and filter as rapidly as possible. Wash thoroughly with water at 65° C. Evaporate the solution to dryness, char, and abstract with dilute nitric acid. Filter and wash thoroughly with water. Burn the residue to a white ash, add it to the solution and bring to complete dryness on sand bath. Take up with hot water and a few cubic centimeters of nitric acid. Digest for one-half hour. Filter and wash thoroughly, and determine phosphoric acid in the solution in the usual way.

Results of Analyses of Soils for Available Phosphoric Acid, by Methods previously described (Soil from Fields of Massachusetts Agricultural College Farm).

No. of Samples.	Moisture.	Total Phosphoric Acid.	Available Phosphoric Acid by $\frac{n}{5}$ Hydrochloric Acid.	Available Phosphoric Acid by 1 Per Cent. Citric Acid.	Available Phosphoric Acid by Neutral Citrate of Ammonia.
1, . . .	.77	.255	.0285	.01325	.0735
2, . . .	.87	.290	.0338	.01650	.0945
3, . . .	.95	.210	.0407	.01420	.0865
4, . . .	1.07	.220	.0330	.01920	.0925
5, . . .	1.02	.180	.0345	.01430	.1070

Analysts: Henri D. Haskins.
Charles I. Goessmann.

Conclusion.

The several modes used by us in determining the amount of available phosphoric acid contained in the soil under examination have given different results. The difference in the amount of available phosphoric acid found by any of the modes of analysis employed does not correspond with the actual yield of the several plats in the field. The results of our investigation are more of a suggestive than decisive character. The work will be continued as far as resources on hand will permit.

6. Analysis of Drainage Waters obtained from Field A of the Hatch Experiment Station.

The field under discussion has been from 1883 to date treated in a systematic way with commercial fertilizers, in the manner briefly described in the following pages. The field consisted of eleven plats, one-tenth of an acre each, with a space of from five to six feet between the adjoining plats. This space was cultivated in connection with the planted plats, yet received no fertilizing material of any description, nor were they seeded down at any time during the experiment. Each plat was provided in the centre with a tile drain running at a depth of from three and a half to four feet through the entire length, which terminated in an open well, to allow the collection of the drainage water for examination whenever desired, to study the character of the soil constituents carried off. The entire field of eleven separate plats were surrounded by a tile drain with an independent outlet, to prevent an access of drainage waters from adjoining fields. A marked gradual decline in the yield of several plats, in spite of a uniform liberal supply of the fertilizer used during the earlier years of the experiment, rendered an examination into the cause or causes of the reduction in the annual yield desirable.

As an examination of the drainage waters coming from the different plats promised to throw some light on the action of the several mixtures of fertilizers used on the soil resources of the field employed in the observation, it was decided to subject them to a careful chemical analysis. The samples used for these analyses were collected in all cases as far as practicable soon after each tile drain began to discharge drainage water. As the temporary flow of the drains in the different plats differed widely in quantity, no attempt was made to ascertain in each case the exact amount discharged in a given time. The examination was instituted for the purpose of ascertaining the general character of the discharge of the drains, and to determine the *relative proportion of various soil constituents they contained.* The results of this investigation are stated farther on, after a brief description of the general management of the field, as well as a detailed statement of the fertilizers used.

Amount of Fertilizing Ingredients used annually per Acre.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen, ...	45 pounds.
	Phosphoric acid, . . .	80 pounds.
	Potassium oxide, . . .	125 pounds.
Plats 4, 7, 9, ...	Nitrogen, . . .	none.
	Phosphoric acid, . . .	80 pounds.
	Potassium oxide, . . .	125 pounds.

One plat, marked 0, received its main supply of phosphoric acid, potassium oxide and nitrogen in form of barn-yard manure; the latter was carefully analyzed before being applied, to determine the amount required to secure, as far as practicable, the desired corresponding proportion of the three essential fertilizing constituents. The deficiency in potassium oxide and phosphoric acid was supplied by potash-magnesia sulphate and dissolved bone-black. The fertilizer for this plat consisted of 800 pounds of barn-yard manure, 32 pounds of potash-magnesia sulphate and 18 pounds of dissolved bone-black.

The mechanical preparation of the soil, the incorporation of the manurial substances, — the general character of the latter being the same, — the seeding, cultivating and harvesting were carried on year after year in a like manner and as far as practicable on the same day in case of every plat during the same year.

The subsequent tabular statement shows the annual application and special distribution of the manurial substances with reference to each plat since 1889. The fertilizers were in every case applied broadcast as early in the spring as circumstances permitted. They were well harrowed under before the seed was planted in rows by a seed drill.

PLATS (One-tenth Acre).	Annual Supply of Manurial Substances.
Plat 0, . .	800 lbs. of barn-yard manure, 32 lbs. of potash-magnesia sulphate and 18 lbs. of dissolved bone-black.
Plat 1, . .	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

PLATS (One-tenth Acre).	Annual Supply of Manurial Substances.
Plat 2, . .	29 lbs. sodium nitrate (=4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 3, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. phosphoric acid).
Plat 4, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 5, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen) 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 6, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 7, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 8, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 9, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 10, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).

The above-described course of the general management of the experiment has been followed thus far for five consecutive years (1889–93, inclusive).

Kind of Crops Raised.

Corn (maize), ...	in 1889.
Oats, ...	in 1890.
Rye, ...	in 1891.
Soy bean, ...	in 1892.
Oats, ...	in 1893.

Amount of Fertilizing Ingredients applied per Acre during 1894.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen, ...	45 pounds.
	Phosphoric acid, . . .	160 pounds.
	Potassium oxide, . . .	250 pounds.
Plats 4, 7, 9, . . .	Nitrogen, ...	none.
	Phosphoric acid, . . .	160 pounds.
	Potassium oxide, . . .	250 pounds.

PLATS (One-tenth Acre).	Manurial Substances Applied.
Plat 0, . .	800 lbs. barn-yard manure, 80½ lbs. potash-magnesia sulphate and 77 lbs. dissolved bone-black.
Plat 1, . .	29 lbs. sodium nitrate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 2, . .	29 lbs. nitrate of soda (=4 to 5 lbs. nitrogen), 97 lbs. potash-magnesia sulphate (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 3, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
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Plat 9, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 10, . .	43 lbs. dried blood (=4 to 5 lbs. nitrogen), 97 lbs. sulphate of potash-magnesia (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).

Analysis of Drainage Water (Per Cent).

100 parts of total solids contain: —

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Potassium oxide,	.600	.380	1.210	.637	.700	.125	.544	2.080	.2740	.5100	.410
Sodium oxide,	21.630	23.850	50.180	5.310	16.670	6.290	6.960	20.890	13.6200	25.6400	5.000
Calcium oxide,	14.210	10.660	12.090	18.340	21.870	23.070	20.720	22.800	26.1900	20.7700	7.240
Magnesium oxide,	6.630	5.390	4.160	5.120	5.340	6.980	4.846	4.680	3.8750	3.9600	2.380
Actual ammonia,	.076	.027	.070	.023	.038	.021	.018	.031	.0068	.0100	.025
Albuminoid ammonia,	.525	.043	.108	.185	.077	.302	.338	.068	.0500	.0560	.073
Ammonia as nitrates,	.565	.242	.765	.349	.331	.298	.708	.153	.3920	.0289	.105
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	trace	.1210	trace	trace
Sulphuric acid,	20.260	2.010	22.810	7.920	1.470	52.820	18.970	6.090	5.7500	4.4600	28.530
Chlorine,	16.150	26.390	6.040	28.380	38.210	2.420	24.610	35.470	32.0700	36.4100	1.020
Silica,	7.700	3.580	.637	4.950	3.160	3.220	5.576	2.570	2.2260	2.8900	.864

Analysts: HENRI D. HASKINS.
ROBERT H. SMITH.

Drainage Water (Results computed in Percentages).

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Total solids,	.0080500	.0265000	.0182000	.0303000	.0256500	.0248000	.0260000	.0265000	.0530000	.0346000	.0787000
Potassium oxide,	.0000480	.0001000	.0002200	.0001930	.0001780	.0000310	.0001415	.0005500	.0001450	.0001770	.0003260
Sodium oxide,	.0017409	.0062205	.0091333	.0016100	.0042728	.0015600	.0018100	.0055366	.0072200	.0088740	.0039344
Calcium oxide,	.0012441	.0028259	.0021997	.0055600	.0056106	.0057200	.0053880	.0059319	.0138820	.0071880	.0057012
Magnesium oxide,	.0005333	.0014272	.0007567	.0015500	.0013693	.0017300	.0012600	.0012396	.0020540	.0013690	.0018738
Free ammonia,	.0000610	.0000072	.0000118	.0000070	.0000098	.0000052	.0000048	.0000078	.0000036	.0000036	.0000197
Albuminoid ammonia,	.0000420	.0000114	.0000198	.0000562	.0000195	.0000750	.0000880	.0000184	.0000267	.0001094	.0000432
Ammonia as nitrates,	.0000460	.0000640	.0001400	.0001060	.0000830	.0000740	.0001840	.0000410	.0002080	.0000100	.0000830
Total ammonia,	.0001490	.0000826	.0001716	.0001692	.0001123	.0001540	.0002770	.0000672	.0002383	.0001230	.0001459
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	trace	.0000640	trace	trace
Sulphuric acid,	.0016311	.0005322	.0041511	.0024000	.0003777	.0131000	.0049340	.0016139	.0030500	.0015450	.0224548
Chlorine,	.0013000	.0070000	.0011000	.0086000	.0098000	.0006000	.0064000	.0094000	.0170000	.0126000	.0008000
Silica,	.0006200	.0009500	.0011600	.0015000	.0008100	.0008000	.0014500	.0006800	.0011800	.0010000	.0006800

Without any intention to discuss here in detail the causes of the variations noticed in the composition of the saline residues left when evaporating a definite amount of the drainage water collected from the various plats, it remains of especial interest to call attention to the fact that wherever muriate of potash had been used as a potash source of plant food exceptional quantities of the chlorides of calcium and magnesium proved to be present (plats 1, 3, 4, 6, 7, 8 and 9). The belief that a liberal use of muriate of potash had resulted in wasting in an exceptional degree in particular the lime resources of the soil, and thereby reducing the yield of the crops, has since been confirmed. The annual yield of the crops has been restored to its former satisfactory condition, after a liberal addition of air-slaked lime to the manures used for years upon the field in question.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Scope of Work.
Pathogenic Fungi.
  Diseases of the Walnut, Maple, Oak, Peach, Plum, Cherry, Melon, Cabbage, Lettuce, Chrysanthemum and Pansy.
Physiological Disorders.
  Seasonal Peculiarities of Certain Shade Trees.
  Over-feeding of Plants.
  Bronzing of Roses.
  Cucumber Wilt.
  Some Difficulties which City Shade Trees have to contend with.

Scope of Work.

This division has during the past year made special effort to come into direct contact with a large number of market gardeners and greenhouse growers; and, largely as a result of this more direct contact and the numerous visits made to their establishments, our correspondence has during the past year doubled that of any other year, and has covered a multitude of subjects relating to botany.

We have paid some attention this summer to the asparagus rust, which caused so much damage in this State in 1897. A study of the conditions which caused the rust has been made at various places throughout the State, and spraying experiments have been carried on in co-operation with different asparagus growers.

The results of the study of nematode worms in greenhouses, which has received a great deal of attention by this division for over three years, have been published in Bulletin No. 55, which can be had on application. This bulletin, containing 67 pages and 14 plates, gives a full account of the parasitic species of nematode, its life history and development, together with the results of an extensive series of experiments on the methods of controlling the pest. In these investigations the worthlessness of many supposed remedies has been brought out, and a practical method of treatment developed by which the trouble can be successfully and economically avoided. From a considerable amount of data accumulated during the last three years it appears that the loss experienced by cucumber growers who have been troubled with nematodes in the greenhouse equals 25 to 85 per cent. of the marketable crop; and it is hoped, from the positive results obtained, that little trouble may be experienced hereafter with this pest. There are still, however, some further experiments being made upon nematode-control methods, in co-operation with large greenhouse growers, along lines which promise cheaper and efficient results.

The principal investigations with which this division is concerned at present are largely in connection with market-garden crops such as are cultivated in greenhouses. The division is supplied with greenhouses excellently arranged for experimental purposes, and containing space enough to carry on investigations from which reliable deductions can be drawn. The more important greenhouse crops grown in our greenhouses for experimental purposes are those representing considerable importance in this State, namely, lettuce, cucumbers and tomatoes; and it may be justly said that there is no class of agricultural pursuits which is represented by men of greater intelligence, skill and knowledge.

A brief outline of some of the investigations may not be out of place: —

(*a*) Experiments on the control of the "drop" in lettuce, and a study of the little known habits of the fungus causing the same. A lettuce house, 40 by 12 feet, is devoted to these experiments.

(*b*) Observations on the "top-burn" in lettuce.

(*c*) Experiments on the mechanical conditions of the soil, as affecting the growth of lettuce.

(*d*) Sub-irrigation, as affecting lettuce diseases.

(*e*) Experiments on the pruning of cucumbers, in relation to the maturity and production of fruit; also, observations on the various fungous diseases of the cucumber, and the conditions which favor them.

(*f*) Experiments on the pruning of tomatoes, in relation to the production and maturity of fruit; a study of the fungous diseases of the tomato.

(*g*) Experiments on the growth of violets in sterilized soil and nematode-infested earth, with special reference to the relationship existing between the size, maturity and production of flowers in the plants, and abundance of leaf spots.

(*h*) Experiments with gases and chemical solutions for disinfecting greenhouses and repression of fungi.

(*i*) Further experiments on the relationship existing between electricity and plant growth.

There are a host of fungous diseases common to our out-of-door plants, some of which have received special attention, such, for example, as the asparagus rust, aster disease, etc.; but the practice of spraying fruit trees and garden crops has for many years been largely carried out by the horticultural division, which is well equipped with all of the modern spraying appliances.

A few years ago it was generally believed by the majority of people that botany was incapable of being made of any practical use, and it is doing no injustice to truth to state that it did possess little at that time. To-day, however, this state of affairs has entirely changed, and botany, like chemistry and other allied sciences, has taken its place in the industrial arts, — a fact which is due to the advance of science in general, but more especially to the inherent genius characteristic of the American investigator, which naturally emphasizes the utilitarian aspect of science. The annual loss in the United States to agricultural, horticultural and floricultural products caused by pathogenic fungi and their allies will probably equal $10,000,000. It is, therefore, not only important, but perfectly legitimate, that the principal work of botanists in our numerous experiment stations should consist in studying the life history of these organisms with a view to their repression. In regard to the industrial side of botany, it should not be forgotten that it owes a great deal to the patient investigations of the many scientific workers of the past, who have devoted their attention to matters of purely scientific interest; and our stations would not be where they are to-day were it not for the labors of these men.

In connection with the characteristic utilitarian features of the present American botanists, it may be of some interest to observe the differences existing between European and American methods of combating pests. Some of the most effective spraying solutions were discovered in Europe, but the methods of applying them and the results obtained by their use to our crops far exceed anything ever accomplished there. To one who has paid any attention to the manner of growing plants in Europe and the methods which are pursued in the control of plant diseases, it would seem no exaggeration to state that more is accomplished in this direction in the United States in one year than in Europe in five years.

The past season has been what might be termed a normal one, although, as in every season, some fungi were especially predominant. There are, however, every year types of fungous diseases which affect our shade trees.

Pathogenic Fungi.

The fungous diseases which have been specially common upon our shade trees this last season are as follows: —

Black Spot of the Maple (Rhytisma acerinum, (P), Fr.).

This fungus is characterized by elevated black spots or blotches upon the surface of the leaf, and, while it is not uncommon to a few maples, it has been especially abundant on the silver maple.

Oak Leaf Blight (*Gloeosporium nervisequum*, (*Fckl.*), *Sacc.*).

A fungus apparently identical with that which causes the blight of the sycamore is sometimes found upon the white oak. This produces large dead blotches upon affected leaves, and causes great disfiguration of white oak trees.

Walnut Leaf Blight (*Gloeosporium Juglandis*, (*Lib.*), *Mont.*).

This disease was mentioned in our last report as having been especially abundant during 1897. It has also occurred this year, but to a much less extent.

These diseases are briefly mentioned because complaint has been frequent during the past summer in regard to them, largely, however, from people who possess shade trees which they value. From what we know in regard to the treatment of similar fungi occurring on other plants, it would seem that spraying might hold some of these in check; and the only reply which can be made is, Are the trees valuable enough to receive treatment? Some of these fungi attack large groves, and the expense of spraying would amount to considerable. As a rule, these fungi only make their appearance at intervals, and do not injure the trees to any great extent. In consideration of this fact, it appears questionable to us whether they are worth the trouble; but, should spraying be deemed necessary, it would have to be done early and continued each year.

The disease of the peach known as the "leaf curl" (*Exoascus deformans*, Fckl.) has been unusually abundant during the past season. This disease is well known to most peach growers, causing the leaves to become wrinkled and curled and greatly deformed, finally resulting in their falling to the ground. It is not ordinarily regarded as an especially destructive disease, and does not often cause any appreciable damage to the tree; but, when so abundant as to cause a large proportion of the leaves to fall, it cannot but injure the tree to some extent.

Another disease of the stone fruits, the so-called "plum pockets" (*Exoascus Pruni*, Fckl.), which causes young plants to become swollen and distorted in a peculiar manner, has been received several times this year. Besides the plum (*Prunus domestica*), the wild cherry (*Prunus Virginiana*) is also affected by the same fungus. The disease is not often very abundant, but occasionally causes a considerable diminution of the crop.

For methods of controlling the various diseases of the peach, plum and cherry, consult the spraying bulletin annually issued by the horticultural division of this station.

A Musk-melon Disease.

During the latter part of August our attention was called to a field of musk-melons, in which a destructive disease of the leaves had appeared and seemed to be rapidly increasing. The owner informed us that he had lost his entire crop the year before in the same way. It was evident that the trouble began in the centre of the hills. Here the leaves at the time of our first visit had in many hills wilted and begun to turn yellow and partially died. They were covered with yellow spots, or, in the worst cases, with dead areas of considerable size. At this time the general appearance of the field was good, the only very noticeably affected places being these centres of some of the hills. Still, it could be seen on closer examination that scarcely a leaf in the whole field was entirely healthy. On almost every one there were small yellow spots, more or less abundant, some were slightly wilted, and it was evident enough that the disease was spreading in each hill from the centre outward. The dead areas on the most affected leaves were dry and brittle, marked with slight concentric rings, and a dark, mould-like growth could be seen upon them. Examined with the microscope, this proved to be a fungus, and a species of *Alternaria*. It grew abundantly in the tissue of the leaf as well as upon the surface, where the dark-brown, club-shaped spores were produced. No other fungus or other organism could be found on the affected leaves, and there seemed but little doubt that this was the direct cause of the trouble. Furthermore, Dr. W.

C. Sturgis,* who describes what is evidently the same disease in Connecticut, has succeeded in producing it by inoculating sound leaves with the fungus, thus leaving no doubt that the *Alternaria* is the cause of the trouble. This fungus is a mould-like growth, consisting of a mass of fine filaments which grow upon and in the leaf, consuming its substance and vitality. It reproduces itself by the above-mentioned spores, which are blown by the wind from the surface of the affected leaves to fresh ones, and there germinate and produce the disease. It is not entirely clear why the leaves near the centre of the hill should be the first to show the disease, unless, perhaps, it is because they are the oldest leaves, and thus are growing less vigorously than the outer ones, and less able to resist the attacks of such a fungus. It should not be supposed that the disease spreads outward to the other leaves through the plant itself, as the nature of the fungus shows that this is not the case, but that it spreads entirely by means of the spores which are carried through the air.

As the disease was so far advanced when we first saw it, it was pretty evident that no treatment would be of much avail in checking it. A portion of the field was sprayed with Bordeaux mixture, but the weather continued, as it had been for some time previous, very rainy, and before a second spraying could be made almost every leaf in the field was dead and withered. Some of the melons had reached sufficient size to mature, but nothing like a full crop was obtained. The same disease was met with in one other locality during the season, and no doubt occurred in various parts of the State, though melon-raising is not much practised here. There is no apparent reason why this disease should not be as successfully treated by spraying with Bordeaux mixture as are many similiar ones which are largely prevented by this means. Experiments will be made another season by spraying at the time of blossoming, and several times thereafter during the season. Knowing the nature of

* Report Connecticut Agricultural Experiment Station, 19 (1895), p. 186, and 20 (1896), p. 267. See also Ohio Bulletin 73, p. 235, and 89, p. 117; Journal Mycology, vii, p. 373.

the disease, it will of course be at once understood that it is very advisable to destroy all affected vines and leaves by burning. It might also be safer not to plant melons on land where the disease had already occurred during the previous season. We do not, however, lay great stress on this, as many farmers have a particular area especially suited to this crop, which they do not like to give up, and the disease is probably disseminated widely enough so that it is about as likely to occur in one place as another.

Rotting of Cabbage.

The rotting of cabbage in the field, caused by a species of bacteria, which has recently been so thoroughly investigated by Russell* and Smith,† appeared this year in a field upon the station grounds, and also occurred to our knowledge in several other places in the State. It is a most destructive disease, causing dead spots to appear upon the outer leaves of the cabbage, and usually resulting in a complete decay of the whole head. Cauliflower is quite susceptible, as also cabbages and turnips. A full description of the disease may be obtained in the above-cited Farmers' Bulletin, which can be obtained upon application to the Secretary of Agriculture, Washington, D. C. No practical remedy is known except a rotation of crops. As the disease occurred here on land which had never been in cabbages before, even this seems rather uncertain.

Further Considerations in Regard to the Drop in Lettuce.

We have already referred to this disease in our last annual report, and it may not be out of place to briefly call attention to the progress which has been made towards the control of this troublesome fungus. The study of the organism which causes the disease has given some suggestive results in regard to its treatment. The ordinary "damping fungus" (*Botrytis*), has been generally regarded as the source of the trouble, and we have so referred to it in our previous report. Further observation has shown, however, that, whatever may

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* Bulletin 65, Wisconsin Experiment Station.

† Farmers' Bulletin 68, United States Department Agriculture.

be the relation between the drop fungus and *Botrytis*, it is certain that the disease is not spread by *Botrytis* spores in the air, but by a mycelium or mould-like growth in the soil itself.

Our control experiments have so far been along three different lines; namely, those in which chemical substances were used on the soil, the application of various gases to the greenhouse, and the effect of different layers of sand and sterilized earth. The results obtained by the use of chemical substances have been entirely negative, and the use of gases does not at the present time give great encouragement. In our last report we called attention to the use of sterilized soil as a possible control method, and during the past winter and also at the present time this method has been in use. Our experiments have shown that the heating method is the only absolute one, although some gain has been made by the use of three-fourths of an inch of sand upon the beds. The sand which was sterilized showed better results than the unsterilized. In both instances, however, cleaner and better plants have been obtained by the use of three-fourths or one-half of an inch placed upon the surface of the soil. Experiments in which three or four inches of the top soil was sterilized gave absolute results in the control of the drop, and those in which two inches of the infected top soil was sterilized have not as yet shown any evidences of the drop. Where one inch of sterilized soil was used and carefully distributed, the loss from the drop has been about four per cent., while in the adjacent beds which were not sterilized the loss was about fifty per cent. These experiments have been carried out in another badly infested house, managed by an experienced lettuce grower, on a much larger scale, with quite similar results.

While this method gives promise of being a practical one, we are not quite certain as yet whether it is the cheapest one which can be utilized, and other control methods are being experimented with. Some growers clean their houses out every year, and put in fresh subsoil mixed with horse manure; but such a method is expensive, probably more so than the heating of an inch or two of the top soil previous to planting the crop. If one is provided with a good steam boiler, as most lettuce growers are, probably two hundred cubic feet of soil could be heated sufficiently in one or two hours' time. This amount of earth will cover twenty-four hundred square feet of soil one inch deep, or a bed twenty-four feet wide by one hundred feet long. Of course this heating will have to be done with every crop, as the stirring of the soil subsequent to planting would redistribute the fungus. As a necessary precaution against the drop, it would also be necessary to have all the soil sterilized in which the prickers are started, and also that which contains the first transplanting. By this means alone much lessening of the drop could be accomplished; but in conjunction with sterilized layers one inch thick in the house, it would in most cases reduce the infection still further. The amount of earth that is employed in the seed bed and also that in which the first transplanting is done is not so large but that it could be entirely sterilized. When this is once accomplished, it would be sufficient for some time to come, provided precautions were taken against outside contamination. The benefits gained from the use of sterilized soil are in themselves, regardless of the drop, sufficient to pay for the process, according to some who have used it, inasmuch as the lettuce plant shows a better color and makes a quicker and larger growth.

The Chrysanthemum Rust.

This comparatively new disease has been not uncommon in the State during the past season; but it is encouraging to note that its attacks seem in most cases where it has occurred to have had but little appreciable effect, and the indications now are that this disease is one which may be fully controlled by proper methods of cultivation and management. We noticed especially a case where a lot of plants were brought in in August to set out in the open bed for fall blooming. Fifteen plants were left over, and remained standing on a greenhouse bench in pots. Later in the season this bench was filled up with other potted plants which had remained out of doors. Though all were of the same lot, the fifteen became badly rusted, while none of the others or those set out in open beds showed any signs of the disease. It seemed pretty evident, therefore, that the high August temperature of the house had a bad effect upon the plants confined in pots, causing them to be more susceptible to the disease. Some of the plants which were still out of doors in a cold frame also became rusted, but these were crowded together so that all the lower leaves had fallen off, and were plainly in poor condition. Of the many plants which were set out in open beds in August or placed on benches with space between them in September, not one showed any noticeable rusting.

It remains to be said that the rusted plants, though badly affected, produced blossoms as good, apparently, both in quality and quantity, as similar healthy plants, and, furthermore, did not spread the disease to other plants, though kept in close proximity to them. Judging, therefore, from this year's experience, it seems probable that the skilful gardener has no great cause for apprehension in this disease.

A New Pansy Disease.

During the past summer our attention was called to a field of pansies at the establishment of a local seed grower, in which the plants were badly affected by a disease of the leaves and blossoms. Upon the affected leaves first appeared small dead spots, each surrounded by a definite black border. These spots soon increased in size, and in the later stages of the disease the affected leaves had an appearance very similar to that of the violet leaf spot (*Cercospora Violæ*, Sacc.). Many plants were killed outright by the disease, and all affected ones were in very poor condition. Besides the spotting of the leaves, many of the blossoms also were affected, the petals being disfigured by dead spots and blotches upon them, while some of the flowers were malformed or only partly developed. The latter was indeed one of the most serious features of the trouble, as the plants were raised for seed, and the yield was greatly reduced by this failure of the blossoms to develop properly.

It was thought at first, from the general resemblance of the leaf spots and close relationship of the two plants, that this might be identical with the violet disease. This, however, did not prove to be the case. Examination showed that the cause of the trouble was a fungus, but one of quite a different nature from *Cercospora*, and belonging to the genus *Colletotrichum*, being apparently a new and undescribed species. This form has therefore been described in the "Botanical Gazette" of March, 1899, under the name *Colletotrichum Violæ — tricoloris.*

This same disease has been seen in a few other localities in the State, and Prof. B. D. Halsted has also very kindly sent us specimens of it from New Jersey, so that the trouble is doubtless widespread. Its occurrence, however, seems to have been comparatively slight, except in the one instance described above. In this case the number of plants was very large, and pansies had been grown upon the same field for several years, which may account for the severe outbreak of the disease.

A portion of this field was sprayed twice with strong Bordeaux mixture; but, as it was already late in the season, and heavy rains prevailed at the time, little success from the treatment was looked for. The owner, however, thought that a beneficial result appeared from the treatment, and from our own observation we can claim at least that later in the season the sprayed portion of the field was certainly in the best condition of any. If this did indeed result from the spraying under such adverse conditions, it seems likely that the disease could be kept well in check by proper treatment.

Physiological Disorders.

Seasonal Peculiarities of Certain Shade Trees.

Some complaints have been made in regard to the falling of leaves on the elm, maple and apple trees. This was especially noticeable on the elm in various sections. We had many specimens sent in for examination, and our attention was called to a number of trees in which certain branches had only half-developed leaves on them. These leaves would linger along a while in this condition, when they would gradually turn yellow and drop to the ground.

Examination made of a great many leaves and branches revealed no fungous or insect pest preying upon them. The condition of the apple trees was similar, although not so prevalent; and in the maple the cast-off leaves were mature ones. The exact cause of this trouble is not obvious, but there can be little doubt that it was a functional disorder. We have observed fine specimens of elm trees, which, after a period of excessive seasons, would suddenly lose all their leaves in midsummer, yet a year or two later would appear as vigorous as ever. Inasmuch as the trees are not materially injured by the falling of a few leaves in midsummer, remedial measures are not necessary.

Over-feeding of Plants.

The over-feeding of plants is not an uncommon occurrence at the present time, when so much concentrated fertilizer is used, and where attention is not given to the proper amounts that should be employed. This trouble not only occurs among florists, etc., but among those who cultivate house plants as well; and the cause of the trouble is usually traceable to the fact that most people are not aware of the strength of the constituents serving as plant food. The normal strength of chemically pure solutions, available for plants, is about one to one thousand or one to two thousand parts, and when these solutions are put on at the rate of one to one hundred or so, ill results must be expected to follow their use.

We now and then have specimens of abnormal plants sent in to us which are merely suffering from some such treatment. A potted specimen of a Johnsonian lily, which had a number of reddish eruptions or blisters upon its leaves, was sent in for examination. These reddish blisters were examined under the microscope, and they showed no evidence of fungi or insects being present. The cells, however, in the vicinity of the blisters showed that they had been stimulated exceedingly, which manifested itself in excessive cell division, giving rise to the blisters; and where this action had taken place excessively the tissues were ruptured, thus producing a ragged, wounded appearance. This trouble could be readily referred to some abnormal features in connection with nutrition, and an inquiry showed that the plants had been heavily fertilized with Chili saltpetre. The same treatment was applied by us to a perfectly healthy Johnsonian lily, with the result that the same activity was shown in the division of the leaf cells, which subsequently gave rise to blisters or ragged eruptions identical with those described.

A number of potted specimens of cyclamens grown by a florist were also brought to our notice last winter, which showed somewhat similiar peculiarities in the leaf. These leaves were blistered, although in quite a different manner from the Johnsonian lily mentioned above. There were no ragged or lacerated eruptions or pustules on the cyclamens, and the manner of blistering was quite different, although it was evidently caused by over-feeding, or at least by injudicious feeding, as it was found that the plants had been heavily treated with nitrate of soda.

A singular case of over-fertilizing or perhaps over-watering was seen in some specimens of carnations sent in to us by a grower. We subsequently visited the greenhouse where they were found, and had an opportunity of seeing these abnormal plants in the benches, beside other plants of the same variety that were not affected. About fifty plants in this house showed this trouble, and it was confined to the most robust specimens of the variety known as the Edith Foster, and in some instances to the Mrs. Fisher. The characteristics of these diseased plants were whitish stems and foliage, which were enlarged to about twice the size of normal ones growing next to them. Repeated examinations of the tissues of the affected plants seem to show that there was nothing the matter with them except what might be expected from improper nutritive conditions, such as might be brought about by too much fertilizer or excessive watering, which caused the plants to be stimulated abnormally in their growth. In the spring the plants were removed from the greenhouse into fresh garden soil, but they failed to recover. The same variety of carnations has already shown similar symptoms this season.

Injudicious use of fertilizers is not an uncommon matter, and more care should be exercised in their application. Most fertilizer companies give explicit directions as to the amounts which should be employed, and the excessive use of them is generally traced to the carelessness of the gardener in applying them. The results of over-feeding generally manifest themselves in some abnormal stimulation to the plant; but these results, even when the same fertilizer is used, do not show themselves in a similar manner on different species of plants. What would give rise to a multiplication of cells and the formation of blisters in the leaf of one plant, would not do it in the leaf of another. In short, stimuli in plants manifest themselves specifically and manifoldly.

The Bronzing of Rose Leaves.

A peculiar bronzing or irregular spotting of rose leaves was brought to our attention last winter by Mr. Alexander Montgomery, Jr., a member of the senior class. This peculiarity in the spotting or bronzing of the leaf is common to grafted varieties of the Tea, Bride and Bridesmaid roses, grown at the extensive Waban conservatories at Natick; and Mr. Montgomery, who was working in the botanical laboratory at that time, made, at my request, some investigations into the cause of the trouble. Both Mr. Montgomery and his father, who is in charge of the Waban conservatories, have had ample opportunity to observe bronzing; and it therefore became a very easy matter to secure valuable data. The only mention which we have noticed in connection with this disease is that given by Professor Halsted of New Jersey, who briefly referred to it in his annual report of 1894.* In this report he gives a figure of the black spot of the rose, and in connection with it is shown what he designates a "discoloration that is most frequently met with on the foliage of the La France, and may be called bronzing." This he states, so far as he knows, is "not due to any fungus, and is likely due to a structural weakness." This reference to the disease by Professor Halsted was not observed until Mr. Montgomery had finished his investiga-

* New Jersey Experiment Station Report, 1894, p. 384.

tions; and, in order to ascertain whether the trouble with which we were concerned was the same which he had briefly alluded to, we forwarded him specimens for examination, which resulted in establishing the identity of the two. There is a certain resemblance between the spots which give rise to bronzing and those which are caused by the black spot; and we found that the impression prevailed among some rose growers that bronzing was simply an immature stage of the black spot. To any one thoroughly familiar with the characteristics of both diseases, the differences between them would be evident, and they would not be likely to confound one with the other.

The investigations of Mr. Montgomery showed that the abnormal condition of the rose leaves subject to bronzing was not in any way connected with fungi, but is of a physiological nature, or structural weakness, as Professor Halsted had correctly surmised. The first symptoms are manifested in a mottled, bronzing coloration of the leaf. These spots subsequently become more prominent, ranging from one-sixteenth of an inch to one inch in size; the infected portions of the leaf frequently turn yellow, and eventually the leaflets and leaf stalk drop to the ground. Sometimes, however, a whole leaflet becomes bronzed, and the yellowish color is not observed. Numerous microscopic cross-sections made of the bronzed leaf spots showed that the epidermal and adjacent cells were in an abnormal condition. The living contents of the cells were disintegrated, the protoplasm and cell walls had turned a reddish-brown color, and numerous very minute bodies about the size of micrococci filled the affected cells. These minute bodies proved upon examination to be crystals of calcium oxalate. The excessive deposits of calcium oxalate indicate that the leaf cells, being unable to obtain sufficient nourishment, were not able to assimilate the calcium salts, and consequently it is deposited in the cells in the form of calcium oxalate. It may be said that all of this phenomenon is nothing extraordinary, but merely concomitant with the death of the leaf, and can be observed in other species of plants. Mr. Montgomery states that the bronzed leaves are more susceptible to disease, and he has observed the occurrence of rust upon them, while healthy leaves would be entirely free.

A further examination of the affected plants at the Waban conservatories, made by Mr. Montgomery and myself, showed that all leaves even of plants subject to it were not affected, but that it was confined in every instance to two places: first, where a stem is cut and a new branch starts, the leaf at the base of the branch begins to bronze; second, when an eye or axillary bud is rubbed off, the leaf generally becomes bronzed.

There is a difference in susceptibility between young plants and old ones. Roses planted in the middle of June show bronzing the first of August, but it is scarcely noticed after the first year's growth. Bronzing appears to occur more largely upon plants which show rapid growth than on those which have grown more slowly; for this reason apparently the root plants or ungrafted ones at the Waban conservatories which are not so vigorous as the grafted ones are not susceptible to it. Bronzing sometimes occurs upon small, weak stock.

It should be stated, however, that, since bronzing occurs on leaves at the axils of the shoots which bear the flowers, no real harm is done to the marketable foliage, as the cutting of the flower stalk is always above the position of the leaves which are bronzed. The most intelligent and successful rose growers always take the most care and pride in their plants, and they are suspicious of any abnormal feature which in any way mars the beauty of them; and this is, so far as we have observed, the only inconvenience which this trouble of bronzing gives rise to.

It is quite evident that we have in the bronzing of rose leaves a physiological phenomenon which is not uncommon to other plants. We have observed a similar falling of the axillary leaves in other species of plants. In the rose it is probably a correlative phenomenon, which is brought about, or at least augmented, by years of cultivation and development along certain lines. Any form of mutilation, whether it be a cut or a mere scratch, acts as a stimulus to a plant; but the manner of reaction of the plant may not always be the same either in kind or degree. As a rule, the cutting of primary organs, such as a shoot, will give rise, among other things, to increased activities in the secondary organs, such as a side shoot or side root; and conversely the cutting of a secondary organ or branch will stimulate the primary organ or main shoot. Then, again, the effects of stimuli caused by cutting are more marked near the source of injury, and less marked the further away an organ is from it. For example, the cutting of the main axis near an eye or bud would give rise to increased activities in the axillary bud, which would manifest itself in the development of a new shoot. The nearer the cut to the eye or bud, the more marked will be the stimulation, or resultant activities, and the more completely will it assume the characteristics of the primary shoot. The better condition the plants are in, and the more suitable and available plant food with which they are supplied, the more rapid will be the growth of the shoot, and the more marked will be the correlative effects. Such, in fact, are some of the laws governing correlation in plants.

In the case of the bronzing and subsequent death of the axillary rose leaves, the stimulative effect of cutting causes a marked growth of the shoot, and the nutritive substances are thereby utilized by this organ to such an extent that some other portion of the plant is made to suffer. In this instance it is the axillary leaf which finally becomes bronzed, turns more or less yellow and dies. In other words, bronzing is nothing more or less than a physiological disorder, and falls under the domain of plant irritability.

Cucumber Wilt.

The growing of cucumbers under glass is carried on extensively in some places in this State, and a disease known as the wilt has been reported to the station a number of different times. Complaints in regard to this disease have always come from certain localities where it has, as a rule, been quite universal among the different growers. The symptoms of the disease are a wilting of the plant, or, more strictly speaking, of the foliage, whenever it is subjected to the intense rays of the sun.

We visited several cucumber houses this last spring in which the plants were subject to wilt, and observed a number of houses which contained badly affected plants. In those houses running north and south, the vines in the morning on the east side, which are subject to the sun's rays, would be entirely wilted; while those on the west side, and away from the sun's rays, were not in the least affected. In the afternoon, when the sun had reached the west side of the house, the vines would then become badly wilted, and those on the east side, when no longer exposed to the direct rays of the sun, would commence slowly to recover. The cause of the wilt in every instance was not difficult to understand; but, as a necessary precaution against drawing deductions too hastily, we examined every portion of a number of plants very carefully, to convince ourselves that there was no other cause than that which we had in mind. It is well known that there is a bacterial disease of cucumbers that gives rise to a wilting of the leaves, but careful examination of the tissues shows nothing in the nature of bacteria to be present.

At about the same time we visited several other cucumber growers in other sections of the State, and had an opportunity of examining many vines in about the same stage of development. In some instances the identical varieties of cucumbers were grown, but in the majority of cases another variety was used, namely, the White Spine, and in all cases the methods of cultivation were radically different, and the wilting of the vines was something unknown to them. Long before we visited the region of wilt a number of letters of inquiry had shown us that the disease in question was local, and the majority of growers had never had trouble with it.

The cause is not due to any organism, whether insect or fungous, but to extremely abnormal conditions of the plants, brought about by irrational methods of cultivation that give rise to defective transpiration, or, in other words, to the giving off of water from the leaves. The activity of transpiration is affected by various causes. It is well known that the stomata or breathing pores of the leaf are open during sunshine and closed during darkness, and that the greatest activity in transpiration takes place during sunshine. This fact is frequently demonstrated by young cucumber plants in tolerably good conditions of health, which not infrequently show some indications of wilt in sunshine, though not enough to cause any amount of harm. This is especially so when they are forced too rapidly, and when the texture of the leaf is not sufficiently developed. The temperature of the air affects transpiration. A plant in an atmosphere saturated with moisture will not exhale any watery vapor, provided that the temperature of the plant is not higher than that of the air; but when the temperature of the air is high, and the proportion of moisture small, transpiration is promoted. Transpiration is further affected by the temperature of the soil in which the roots are embedded. When the roots are warmed, transpiration becomes more active, and consequently there exists more root absorptive activity. The nature of liquids which the roots absorb and the kind of soil in which they grow also affect transpiration. Plants transpire more when grown in sandy soil than when grown in clay soil; also when grown in acid soil than when grown in alkaline soil. One per cent. solutions of potassium nitrate and other salts diminish transpiration, and we have been able to produce severe cases of the wilt by watering pots of cucumber plants with a one per cent. solution of potassium nitrate.

The wilt, however, in the houses mentioned before was not due to temperature or constituents of the soil, but was brought about, as we have already inferred, by irrational methods of treatment of the plants, and depends upon other causes. In all probability, the cause of the wilt may be attributed partially to the characteristic peculiarities of the varieties of cucumbers grown, as most of the varieties are Telegraph or Giant Pera. In many cases hybrid forms are obtained by crossing these with the White Spine. These varieties present a different appearance from the White Spine; their stem and leaves appear to be small, and the plants do not appear normally as green and rugged as the White Spine.

The methods of growing cucumbers where the wilt occurs are radically wrong in many ways. The houses are imperfectly supplied with ventilation, consequently little use can be made of this necessary feature. Then, again, they are supplied either wholly or partially with two layers of glass, which are set about two inches apart, thus leaving an air space in between for the purpose of keeping out the cold, but which in reality becomes filled up with dirt, and is an excellent aid in shutting out the light. Plants started in such a house in winter continually suffer from lack of light, — a feature which we have often observed in the greenhouses in this State. Their leaves become pale, and they are attached to the stalk by means of elongated petioles, and present all the phenomena of partial etiolation, or, in other words, they resemble plants grown in the dark. If we add to such plants an enormously high temperature, without any proper ventilation to make them stocky and rugged, then we have a crop that is so tender and abnormally matured that it is incapable of standing strong sunlight. If such a crop is carried over until spring, and subjected to the intense rays of the sun occurring in that season of the year, the tender, etiolated, sickly colored leaves commence to wilt even with the house closed and a considerable degree of moisture.

We observed as many as a dozen houses last spring affected in this way, and not in a single one did we see more than a dozen or so of what might be termed fairly good-colored and healthy plants. Whenever we observed a plant which possessed any color or texture in its leaves, we found plants which showed no indication of the wilt. We examined at the same time in another locality a crop of a similar variety of cucumbers grown in a house provided with a single layer of glass, which had also received sufficient ventilation, and the plants were in an exceedingly vigorous condition.

These facts show what it is always necessary to bear in mind, that some varieties of plants can be grown by different growers with entirely different results, and that it is essential to pay the greatest attention to conditions which are normal to the plants.

While the cause of the cucumber wilt is due, as we have already pointed out, to irrational methods of greenhouse management, the specific cause can be traced directly to the lack of texture in the plants, brought about by too high a temperature and lack of light in the beginning, which does not enable them to stand up under the powerful rays of the spring sun, as the amount of water thrown off from their tender leaves is more than can be supplied by their roots. This irrational method seems to have its origin in a desire to save coal, and starve the plant by utilizing double layers of glass, and to indulge in too much forcing; or, in other words, to get more out of the plant in a certain length of time than its inherent capacity warrants. In these methods of culture, affecting, as they do, a single locality, we see nothing but practice based upon a disregard of the normal functions of the plant, and mistakes due to local conception of greenhouse management. The remedy in such a case is obvious, and consists in giving the plants during their young stage of growth plenty of light and air, and not allowing them to grow too rapidly. Cucumber plants grown in this manner will possess color and texture, and they will be capable of standing the spring rays of the sun without wilting.

Some Difficulties which City Shade Trees have to contend with.

For some years back our larger cities have had park commissions, whose duty consists, among other things, in seeing to the setting out and caring for shade trees. Many of these cities, having seen the necessity of a more general oversight in regard to the care of trees, have gone a step further, and have secured the services of a trained forester, whose business it is to pay special attention to their welfare.

This department frequently has specimens of diseased leaves and branches, especially of trees, sent to it for the purpose of determining what is the matter with them. Sometimes these specimens are from trees in which a single branch has lost its leaves in mid-summer, or they may be specimens from a tree which has died suddenly. An examination of the specimens frequently shows that there is no reason for believing that their abnormal condition is caused by either insect or fungi, although at times there may be observed a few aphids on them, which it is generally supposed are the cause of the trouble. The causes of these troubles, however, are in many instances to be traced to conditions which are peculiar to our times. In this age of electric lights, trolley cars, sewers, pavements, gas, and transmission of steam for heating purposes, it must be confessed that the practice of setting out shade trees along the borders of streets in our cities becomes rather discouraging. The price of enjoying these modern appliances of scientific thought means more than the mere cost of digging up our city streets and lopping off the limbs of trees every few months; in many instances it means the death of many shade trees, and it may eventually lead to the question whether it is worth while to bother at all with trees for our city streets. The sickly, disfigured, mutilated specimens of trees which are now and then seen in our busy city streets have very little to recommend them, and in many cases thoroughfares would become improved without them.

Some of the agencies which more especially affect our trees are electricity, gas and steam. These may affect the tree directly, by escaping and coming in contact with some portion of it, or indirectly as by the lopping of limbs for wires or the digging of trenches for the pipes, which very frequently results in destroying portions of the root system. There are other agencies, however, which are associated with the death of the tree. One of these is the borer that is very troublesome to the rock maple. Trees affected with these can be readily detected by an examination of the bark of the tree for round holes about one-quarter of an inch in diameter, and in autumn the affected limbs can be readily detected by a premature coloration, or hectic flush, as it were, of the leaves. Then, again, there is the work of horses' teeth, which, according to Mr. James Draper, who has had many years' experience as a park commissioner at Worcester, inflicts more damage than any other single thing to city trees. Many of the specimens of diseased shade trees which are sent in to us year after year can be referred to one of the above agencies as a cause of the trouble.

The death of many trees can be referred to illuminating gas. If a leak occurs in the pipe, the gas escapes very readily into the soil, especially if it is porous, and when it comes in contact with the roots they are asphyxiated, and the result to the tree manifests itself very quickly. The symptoms of gas poisoning are most generally a sudden falling of the leaves, a deadened appearance of the bark, due to the collapse of the cambium or living layer, brought about by the asphyxiation of the roots, which results in the rapid death of the tree. In mild instances of poisoning the effect shows only upon one side of the tree, but in general the tree seldom escapes death. We have observed many single trees killed by gas on the private grounds of city residences, without the owner ever surmising what the trouble was; and this last summer we had an opportunity to examine whole rows of native trees which had died by gas asphyxiation. Some of the trees which we observed were at a distance of fifty feet from the nearest gas main, while others succumbed when not nearer than one hundred feet to the leak in the pipes. While it is advantageous to all gas companies to stop these leaks as soon as they are found, it becomes practically impossible to do so in every instance, and the death of trees from this source must constantly be expected. As a matter of fact, the death of some fine shade tree is not infrequently the first indication the gas company has of a leak in its main.

Abnormal respiratory conditions, which usually result in either a sudden or lingering death to trees, occur where they have become submerged in water, or where they have been covered with a foot or more of soil. We have noticed trees growing beside sloping roadsides which had become filled in with earth only on one side of the tree, resulting in that side of the tree becoming dead, while the other side would linger along in an unhealthy condition for years.

Less often does the death of trees result from steam, as the transmission of this is not so common. Occasionally, however, where steam pipes are laid near trees, they are sometimes injured.

The various forms of concrete and pavements and the large surface of the ground covered by them about the city streets are a menace to the health of trees, and the sickly conditions which they present are often due to these. Some of our more modern city streets obviate this matter by leaving a wide space of turf between the sidewalk and road, for the purpose of planting trees. This gives the roots a chance to develop normally, inasmuch as the respiratory functions are not interfered with, as is the case when they are covered with pavements. Many of the streets in Springfield are especially commendable in this direction.

Not a little of the disfiguration of trees is directly due to the linemen in lopping limbs, and more especially to the direct effect of electric currents. We have observed no instance where electricity has killed a tree outright, but there are many cases where the limbs have been killed by burning. This effect is not only caused by the alternating current of the electric lights, but by the direct current of the trolley system; the latter current being probably more injurious, provided the same amount of amperes and voltage is employed. The damage done by grounded wires takes place when trees are moist, as at that time the resistance is reduced, and the current becomes increased and has a better opportunity to become dispersed. We have known of instances where trees and the grass for some distance about them have been charged with the escaping current. The damage to the trees, however, is due to the heating effect of electricity. The wire becomes grounded on a limb, and when moist the current escapes. At first comparatively little current passes through the limb, as the resistance is high; but, as the heat increases the resistance decreases, with the result that a large amount of current passes through, which gives rise to still more heat, and subsequently develops into a blaze. The action of electricity, as we have already stated, is local in its effects. The injury, while sufficient to kill every portion above the limb or trunk, does not, so far as our observation goes, destroy the tissues very far above the point of grounding. There are reasons for believing, however, that the effects of the direct current are more severe than those of the alternating current. In the case of the alternating current the anode and cathode alternate very quickly, while in the direct current no alternation takes place, and this results in an electrolysis of the cells, which in turn produces disintegration and quick death to the protoplasm. In short, we may say that all of the injury to trees by electricity is brought about by heating, and by electrolysis and disintegration of the cell contents. Some observations made by Professor Hartig of Munich upon the effects of lightning on trees are interesting in connection with the subject of electricity. He observed that when a tree is struck by lightning the current usually travels along the cambium zone or living layer of the tree, just under the bark, inasmuch as at this point the current finds the least resistance. Sometimes the burning effect is more marked just inside and outside of the cambium layer, where the resistance is slightly greater, — a feature which is shown by the dead areas in the trees many years after. There are many trees struck by lightning which show scarcely any injury, and others will show only a small dead area which coincides with the path of the current. Professor Hartig has made many observations upon trees struck by lightning, and his practised eye is able to detect trees that have been so affected which to the ordinary observer would appear perfectly sound.

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